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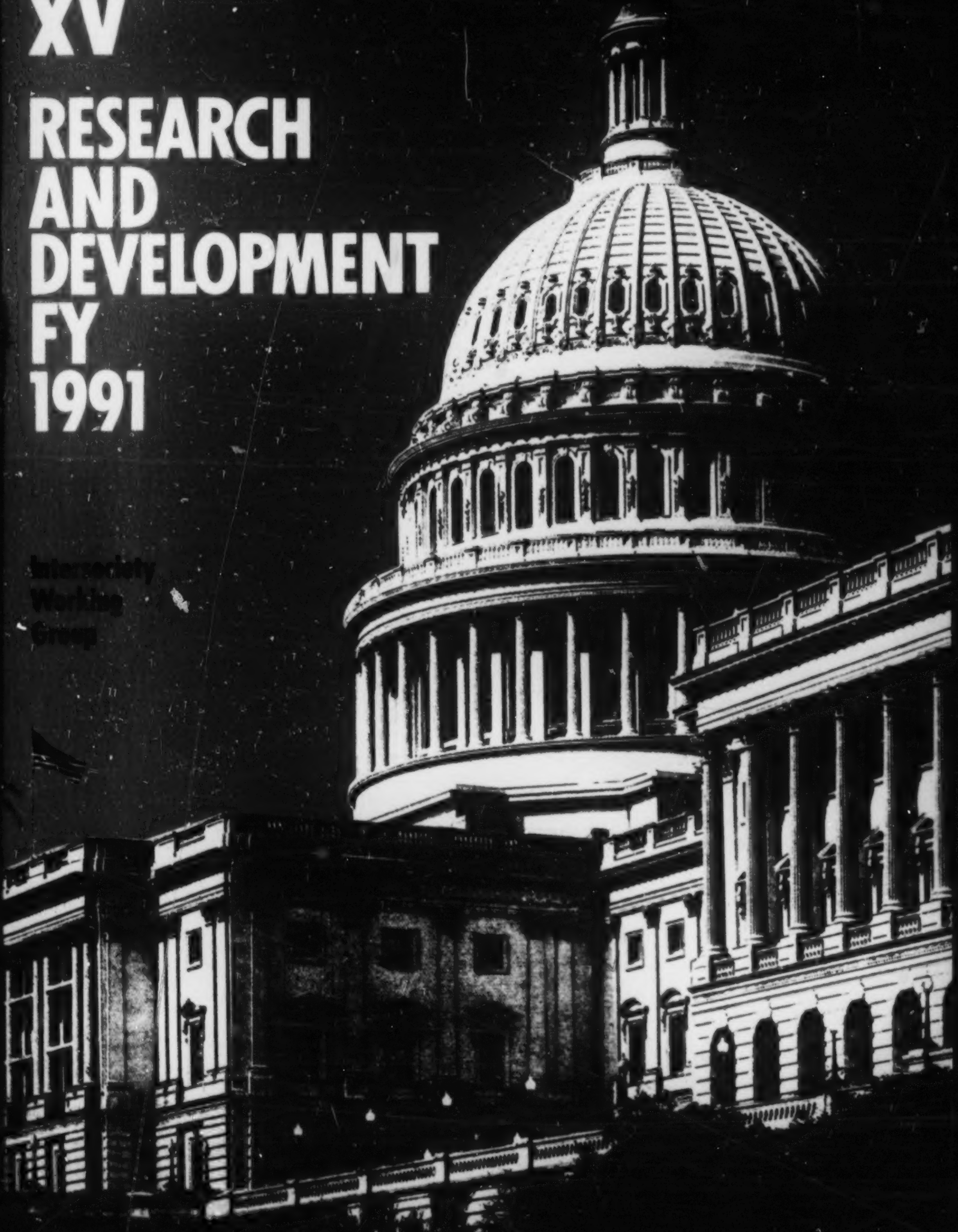
AAAS REPORT XV

RESEARCH AND DEVELOPMENT FY 1991

Intersociety
Working
Group



AAAS REPORT XV

RESEARCH AND DEVELOPMENT FY 1991

Intersociety Working Group

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
Committee on Science, Engineering, and Public Policy
1333 H Street, NW, Washington, DC 20005

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Preface

This annual series of analyses of research and development in the federal budget begun by Willis Shapley in 1976 has reached another milestone in 1990 with publication of volume fifteen. As in past years, the analysis has been conducted under the auspices of the AAAS Committee on Science, Engineering and Public Policy. This year it involves contributors from 22 scientific, engineering, higher education and industrial associations known collectively as the "Intersociety Working Group." The main purpose of the report is to make available to the scientific and engineering communities and to policymakers timely and objective analyses of the Administration's proposed budget for research and development.

Several features have been added this year. The Industrial Research Institute has prepared a chapter on trends in funding of R&D in industry. In addition, the AAAS Directorate for Education and Human Resources Programs has contributed a chapter on funding for science, engineering and mathematics education in the FY 1991 budget. Finally, a section on state support of R&D has been added to Chapter 2, "Special Analyses." While none of these additions is concerned strictly with R&D in the federal budget, all deal with closely related funding and policy matters that help define the context within which federal R&D is discussed and debated.

Seldom have research and development been given as prominent a place in the President's budget as they were in FY 1991. The budget, presented in a rather unconventional manner, featured five themes, of which the first was "investing in the future." Under this heading the document highlights, as its second subtheme, "expanding the human frontier -- space and biotechnology, and the superconducting super collider" and, as its third, "enhancing research and development."

Indeed, once again, relative to most other areas of government expenditure, R&D funding as a whole has done very well. As the analyses in this report suggest, however, understanding the details of the budget is far more important than just knowing the broad outlines. Within the apparently rosy overall picture are many trouble spots and much room for serious debate over priorities. And, with Gramm-Rudman-Hollings's ever more stringent deficit targets and widespread cuts in other domestic programs, expensive, highly visible R&D items will certainly be fair game in the congressional process.

In many respects, the unconventional style in which the President's budget has been presented makes ferreting out details more difficult than in the past. While Richard Darman's charming introduction, which speaks of "green eyeshades," "the Cookie Monster," and "hidden PACMEN," is interesting, informative and refreshingly different from traditional bureaucratic prose, much useful information that has appeared year after year has been buried or omitted entirely from the FY 1991 document. Among the sections consigned to oblivion is "Special Analysis J," a key source of statistical information on federal R&D since the 1960s. Fortunately, OMB has continued to collect the information on which the special analysis is based and we have been able to use it, as well as the agency budget justification documents, in preparing this report.

AAAS Report XV: Research and Development FY 1991 is one of several publications and activities of the AAAS R&D Budget and Policy Project. The report is intended to serve as background for the Fifteenth Annual AAAS Colloquium on Science and Technology Policy held in Washington, D.C. on April 12-13, 1990 and the Fifth Annual AAAS Pacific Division R&D Conference in San Mateo, California, on April 6, 1990.

The Proceedings of the S&T Policy Colloquium will be published by AAAS several months after the meeting. In the fall or winter, after Congress has completed its appropriations process, AAAS, in collaboration with the Intersociety Working Group, will publish its annual review of the impact of congressional decisions on R&D, Congressional Action on R&D in the FY 1991 Budget. Participants in the Washington and California meetings will receive copies of the Colloquium Proceedings, as well as the Congressional Action Report.

The form of this report is similar to editions of the past several years. Part I, the overview, includes discussions of the budgetary context of R&D and major funding trends, as well as an examination of funding for basic research and R&D in colleges and universities. The special section on state R&D and the new chapters on R&D in industry and funding for science, engineering and mathematics education are also included in Part I. A set of overview tables appears at the end of this section.

The R&D budgets of the major federal agencies and departments are described and analyzed in the chapter of Part II. Tables detailing these budgets and the budgets of several smaller agencies and departments not included in the chapters are printed at the end of this section.

Finally, Part III comprises a set of cross-cutting analyses which look at the budget in terms of scientific and engineering disciplines and areas of research.

Readers should be aware that the chapters in this report have been prepared largely independently of one another and under extremely tight deadline pressure. Although every effort has been made to avoid them, some overlap, errors and inconsistencies among the chapters are, unfortunately, inevitable.

On behalf of the members of the Intersociety Working Group, we would like to express our appreciation to the officers, members and staffs of the participating organizations for their support and assistance in preparing this report. A special debt is owed to the AAAS Committee on Science, Engineering and Public Policy, which initiated the R&D Project and periodically reviews it and provides guidance to it. We are also very grateful to the individuals in OMB, in other federal agencies, on congressional staffs and elsewhere, who aided us in collecting the information and advised us on its interpretation. Special thanks are due several AAAS staff members for their assistance in preparing this volume for publication: Beth Goodrich and John Schoneboom of the Directorate for Science and Policy Programs and Sue O'Connell of the Office of Publications.

Finally, some readers who follow these reports from year to year may have noticed the disappearance of the Office of Public Sector Programs from various credit lines. Its policy functions, including the R&D project, were transmogrified into the new, improved Directorate for Science and Policy Programs under a AAAS staff reorganization in 1989.

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Stephen D. Nelson
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Washington, D.C.
March 1990

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GENERAL NOTES

BASIS OF BUDGET STATISTICS

Budget statistics are presented on three bases: (1) **budget authority**, corresponding to the funds appropriated each year; (2) **obligations**, indicating the amounts of contracts and grants entered into; and (3) **outlays**, representing the amounts actually expended. Because budget decisions in the Executive Branch and in Congress are almost always made in budget authority, this basis most accurately reflects current changes in budget policies. Outlay trends lag a year or more behind decisions in budget authority, and obligations estimates are often adjusted to meet fiscal or budget strategy demands. We have, therefore, selected budget authority as the most meaningful measure of budget decisions and trends and used it in nearly all cases throughout the report.

BASIC RESEARCH, APPLIED RESEARCH, AND DEVELOPMENT

The allocation of agency budgets among basic research, applied research, and development is not an exact procedure; a certain arbitrariness is inevitably involved. The severe time pressures under which these figures are compiled for OMB are also a problem. Nevertheless, there is presumably some consistency within each agency's estimates so that the trends are meaningful.

ROUNDING NUMBERS

Due to rounding in the tables, the detail may not add to the totals and the percentage changes may not correspond exactly to the differences shown.

Part I: Overview

Chapter 1

Overview and Policy Issues for FY 1991

American Association for the Advancement of Science

Kathleen M Gramp, Albert H. Teich, Stephen D. Nelson, Susan L. Sauer

Overview and Policy Issues for FY 1991

While there were few surprises in President Bush's FY 1991 plan for research and development (R&D), his budget departs from the well-worn patterns set by his predecessor. For the first time in years, most of the recommended increases are for nondefense R&D. The National Aeronautics and Space Administration (NASA), rather than the Department of Defense (DOD), is the big winner. The development side of the R&D equation remains dominant, but the growth in research is up from prior years. To encourage R&D investment in the private sector, the President recommends making the 20 percent research and experimentation credit permanent.

This overview (1) examines R&D in the context of the total federal budget; (2) reviews the major features and trends in the FY 1991 budget for R&D; and (3) discusses the prospects for R&D spending proposals in the Congress.

A. Political and Economic Context of the FY 1991 Budget

Events throughout the world have recast the debate about the federal budget. As nations in Eastern Europe, Central America, and Africa make dramatic progress toward democracy, this country is taking stock of its role as a military and economic power. Policymakers are raising fundamental questions about use of federal resources at home and abroad.

This introspection is sure to bog down the already beleaguered budget cycle. Recent experience has shown that timely action on the budget requires bipartisan accord on the big issues of defense spending and taxation. Both the pace of world events and domestic political factors make such an agreement unlikely this year.

Defense spending promises to take center stage in the budget debates. Breaking with precedent, President Bush has proposed a 2 percent real decline in the defense budget. With all aspects of defense policy in a state of flux, Congress will be hard pressed to agree on how much to spend for the military. In the meantime, various constituencies, both domestic and international, will be vying for the unquantified "peace dividend."

The Congressional Budget Office (CBO) has offered some parameters for the "peace dividend" debate. CBO estimates that if budget authority for defense declines in real, inflation-adjusted terms by 2 percent per year (consistent with recent trends), spending would be about $4 billion lower in FY 1991 than it would be under an inflation-adjusted base case. The "savings" relative to that baseline would increase to $35 billion by FY 1995.

Not surprisingly, these amounts appear meager when compared to the amount by which Congress must cut the deficit to meet the $64 billion target for FY 1991 set by the Gramm-Rudman-Hollings law (GRH). Even using the Office of Management and Budget's (OMB) comparatively optimistic $101 billion baseline deficit estimate, Congress would have to cut outlays by $27 billion in FY 1991 to avoid sequestration. (The law allows a $10 billion cushion before triggering sequestration.)

CBO, on the other hand, expects the deficit to stall in the $130 billion to $140 billion range for the next few years, assuming a continuation of current policies. For FY 1991, the agency expects the baseline deficit to hit $138 billion. At this level, lawmakers would have to find ways of saving $64 billion. As in past years, most of the discrepancy between the OMB and CBO estimates can be attributed to differing assumptions about the economy and interest rates.

If experience is any guide, Congress can be expected to use OMB's assumptions for its budget scorecard. Doing so makes the chore of meeting the GRH target easier. Equally predictable are disagreements over the President's domestic spending agenda. His budget urges higher spending for R&D and many social programs, but these increases would be offset by cutting Medicare, federal pensions, and energy, community development, and credit programs. The peace dividend and tax policy promise to further stymie a budget accord.

On the tax side, attention has focused on tax cuts. President Bush resubmitted his proposal to reduce the capital gains tax, renewing debates on the progressivity of the federal tax code. Negotiations on the FY 1990 budget faltered until the capital gains issue was dropped. Proposals to restructure the Social Security payroll tax have further ignited the controversy. (For details on how Congress shaped the FY 1990 budget and the effects of its decisions on R&D, see Congressional Action on R&D in the FY 1990 Budget, published by AAAS in January 1990.)

If Congress cannot resolve this slate of policy conflicts, the budget process may revert to mechanical solutions. Last year's budget compromise relied on a partial sequester to reach the deficit target. Many speculate that this could happen again, and suggest that it may be an outcome favored by the Administration.

The President may accept across-the-board cuts because they would have little or no effect on his proposed defense budget. Under the GRH rules, funds are not sequestered unless a program's budget exceeds the prior year appropriation, adjusted for inflation. Since the President has proposed a 2 percent real decline in military spending, most items in the President's defense budget would be untouched by a sequester.

Another political advantage of a sequester is that it only applies to about one-fourth of the federal budget. The GRH law exempts social security and a wide range of entitlement, low income, and other programs from the automatic cuts. Thus, many popular domestic programs would emerge unscathed as well.

Domestic discretionary programs would bear the brunt of this strategy. Outlays for these programs could be cut by up to $18.5 billion, if a sequester is used to make up the entire $37 billion shortfall. (Although the calculations change each year, cutting domestic outlays by $2.9 billion last year translated into a 1.4 percent cut in budget authority.)

At issue is whether the President would tolerate cuts of this magnitude in all discretionary programs. Within this category are many priority programs including, of course, all nondefense R&D.

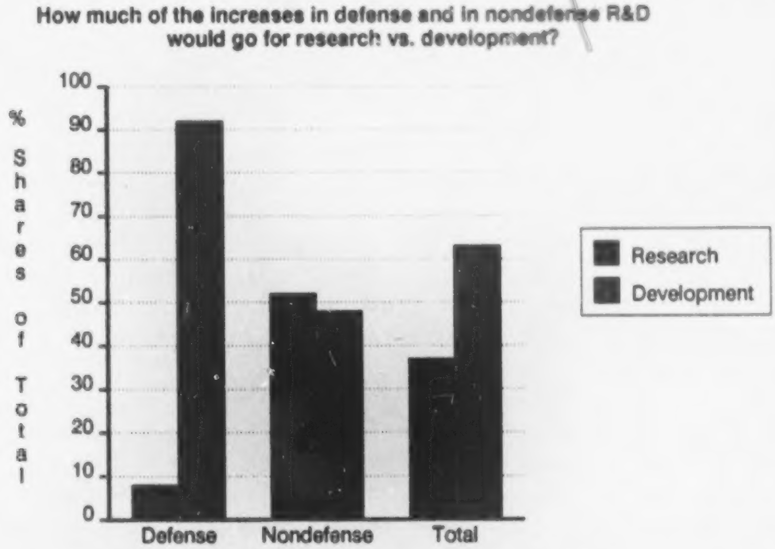
Such cuts would clash with the President's agenda for R&D. He has asked for $71.2 billion for R&D FY 1991, which translates into a $4.4 billion (or 6.7 percent) increase over the FY 1990 enacted level. According to the budget documents, the new federal money would be aimed primarily at research on space, national defense, and biomedical needs.

There are some dramatic differences between the FY 1991 request and past budgets. During his eight years as President, Mr. Reagan recommended giving civilian R&D programs an average of only 15 percent of the "new money" in the budget. Under the Bush budget, nondefense R&D would get 67 percent of the proposed $4.4 billion increase.

The portion allocated to "research" also would go up. Out of the total $4.4 billion increase requested for the conduct of R&D, 37 percent would be dedicated to research (basic and applied), and 63 percent to development (see Figure A). On the civilian side, 52 percent of the new money would be for research. Defense programs would continue to be heavily oriented toward development, with 92 percent of the added funds going for development and testing.

To help put the R&D programs into context, Table I-1 shows how R&D spending fits within the total federal budget. It tracks federal outlays for fiscal years 1989 through 1991 by major spending categories. OMB expects outlays for defense R&D to account for a steady 14 percent of the national defense total. Outlays for nondefense R&D, on the other hand, are projected to grow far faster than their counterparts in the "other government" category (13 percent between FY 1990 and FY 1991, compared to a slight decrease for the remaining programs). If OMB's numbers prove

Figure A



How much of the increases in defense and in nondefense R&D would go for research vs. development?

correct, nondefense R&D would account for 21 percent of the outlays in that category by FY 1991, up from 18 percent in 1990.

Table I-2 looks at outyear trends in federal outlays. OMB has estimated outlays by major category for FY 1991 through FY 1995 for the President's proposals. These projections suggest that defense outlays would decline in real (inflation-adjusted) terms by 9 percent between fiscal years 1991 and 1995. This downward trend in outlays is the product of recent decreases in defense appropriations. Conversely, OMB projects that outlays for "other government" programs would rise by 50 percent in real terms over that same period. The table assumes that R&D outlays would mirror these trends.

B. R&D in the FY 1991 Budget

The remaining tables in Part I (Tables I-3 through I-13) highlight some of the key features of the President's R&D budget for FY 1991. Statistics on agencies' R&D proposals are presented at the end of Part II. The first table in that section (Table II-1) shows the total R&D request by agency. Details on the R&D programs within the major agencies are provided in tables II-2 through II-21. Analyses of the R&D proposals by agency and by discipline are presented in Parts II and III of this report, respectively.

Table I-3 shows how funding is divided between defense and nondefense R&D. It confirms the President's shift in favor of nondefense programs. His FY 1991 proposal would invest 60 percent of the government's total R&D effort into defense, compared to 65 percent in FY 1989. At $42.5 billion in FY 1991, the defense R&D budget would fail to keep pace with inflation (the 3.5 percent rise represents a one percent loss in constant dollars). Budget authority for nondefense programs would grow to $28.7 billion, or by 11.7 percent (6.7 percent in constant dollars) relative to FY 1990.

This table presents the funding trends according to the three common measures of budget transactions: budget authority (BA), obligations, and outlays. (See "General Notes" at the front of this report for the definitions of these terms.) In the defense area, budget authority and outlays would grow in tandem (3.5 percent in current dollars), while the increase in outlays would be slower. The opposite would be true for nondefense programs, where outlay growth would outpace that of budget authority and obligations.

Other highlights of President Bush's FY 1991 request for R&D include the following:

- Space programs would tap half of the new money for nondefense R&D, registering a 31 percent gain over FY 1990 levels (see table I-4). When the other non-space R&D done by the National Aeronautics and Space Administration (NASA) is added in, the agency accounts for 68 percent of the additional funds requested for nondefense R&D. NASA would overtake the Department of Health and Human Services (HHS) as the largest sponsor of nondefense R&D if the budget proposal is enacted.

- General science and health R&D account for most of the remaining growth in the nondefense sector. Funding for general science research, which includes the National Science Foundation (NSF) and the Department of Energy's (DOE) high energy and nuclear physics programs, would increase by 14 percent compared to the current year. The budget for health research would rise about 5 percent, enough to keep pace with inflation.

- Table I-5 displays the budget request by character of work. Basic research leads the list of increases, with a $12.4 billion request (8.5 percent above current levels, or 4.1 percent in constant dollars). The proposal also raises funding for applied research to $10.9 billion (up 6.4 percent and 2.2 percent in current and constant dollars, respectively). Although development still accounts for the largest chunk of the new money, the $44.9 billion request is only 6.7 percent higher than the FY 1990 estimate (or 2.3 percent in constant dollars). The remaining $3 billion would be earmarked for facilities, but this amount represents nearly a 3 percent decline after adjusting for inflation.

- Table I-6 shows the character of work for defense and nondefense R&D. As spending on nondefense R&D rises, so does its share of each type of work. Its domination of basic research would inch up from 91 percent in FY 1989 to 92 percent by FY 1991. It would climb from 71 percent of the applied research to 74 percent during the same period. Finally, defense programs would continue to dominate development, but its 84 percent share in FY 1991 would be down from 89 percent in FY 1989.

- Basic research would be the fastest growing component of the defense R&D budget, posting a 5.8 percent rise in current dollars (although it would remain a very small part of total defense R&D. Funding for development and applied research would fail to keep pace with inflation. The 3.9 percent gain proposed for defense development would come close to covering inflation, but the budget for applied research amounts to almost a 2 percent drop in real resources.

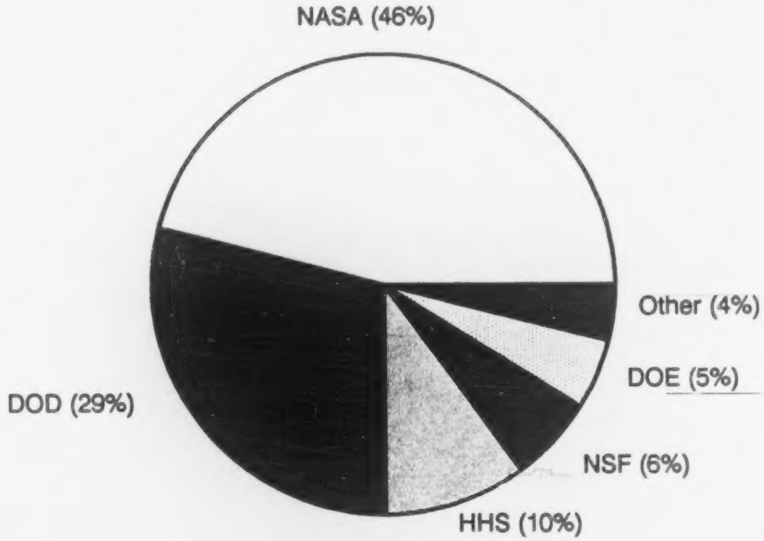
- Within the nondefense category, development tops the growth chart with a 23 percent jump over FY 1990. Almost all of this increase is attributable to NASA. The budget for nondefense basic research is 8.7

percent higher than FY 1990, thanks largely to new spending at the National Institutes of Health (NIH), NASA, and the National Science Foundation (NSF). Similarly, the 8 percent increase proposed for applied research would be driven by money added to the NASA and NIH budgets.

NASA's pre-eminence within the President's FY 1991 agenda can be seen on Table I-7, which lists the proposed R&D budgets for major agencies. In fact, as illustrated in Figure B, three agencies -- NASA and the Departments of Defense and Health and Human Services -- account for 85 percent of the growth in the federal R&D effort.

Figure B

Distribution of FY 1990-91 R&D Increases by Agency



The President would give NASA $2 billion more than was appropriated for FY 1990. Almost 70 percent of the new NASA spending would be for development, including increases for several large projects.

About one-third of $2 billion ($700 million) would be for the development of the Space Station Freedom. NASA also recommends adding $221 million to begin work on the Earth Observing System (EOS), a space-based system for studying global change. Another $431 million would be added for projects related to manned exploration of the moon and Mars, especially for exploratory R&D. Within that total, NASA's contribution toward the National Aerospace Plane project would more than double, reaching $119 million in FY 1991. Finally, funding for R&D in physics and astronomy would rise 14 percent, to $985 million, to finance mission operations, the advanced X-ray astrophysics facility, and other projects.

The largess bestowed on NASA contrasts with the 3 percent increase proposed for R&D supported by the Department of Defense (DOD). The $39.2 billion R&D request adds $1.3 billion to the FY 1990 level, two thirds of which would go for the Strategic Defense Initiative (up $889 million). To keep the departmental average down to a 3 percent increase, the Administration proposes holding tactical programs close to their FY 1990 levels. Funding for technology base initiatives (i.e., basic and applied research) would rise by 3 percent.

All of the new R&D spending proposed for HHS would be dedicated to health issues. The President has requested $9 billion for HHS R&D in FY 1991, which exceeds the FY 1990 level by $446 million (5 percent in current dollars). As the largest R&D agency within HHS, NIH would receive the bulk of the increase (up $343 million, or 4.6 percent). Most of the new money would be spread quite evenly among the institutes, with the exception of the human genome budget (which would rise 82 percent to $103 million). AIDS-related R&D accounts for less than 20 percent of the proposed increase for NIH and HHS. Funding for R&D on human services would fall by close to 3 percent in current dollars.

NSF remains at the forefront of the President's strategy for advancing R&D. Repeating past proposals, the Administration seeks a doubling of the NSF budget within the next five years. The $2.1 billion request would add $251 million to current levels, giving NSF a 13.3 percent increase. Here, too, most of the directorates would receive comparable increases. Geosciences research shows the largest percentage gain (up $59 million, or 18.1 percent), but math and physical sciences would add the most money (up $65 million, or 11.6 percent). The President also advocates higher spending on science education programs (up $46.7

million, or 22.8 percent), but these initiatives are not counted as R&D.

Within the Department of Energy (DOE), there are three separate R&D categories, each with its own agenda. Under the President's plan, DOE's R&D budget would go up by an average of 3.1 percent to $7.4 billion in FY 1991. The 16 percent growth proposed for general science and research exceeds that norm. Over half of this increase would be for building the Superconducting Super Collider (SSC). For defense-related R&D, the Administration wants a 4.4 percent increase over FY 1990, which covers inflation and allows for additional R&D on environmental restoration of defense sites. Offsetting these increases is the President's proposed cut in civilian energy R&D, which would fall 3.3 percent compared to FY 1990. Coal research would be hard hit, but funding for R&D on certain other energy sources, notably solar energy, would go up.

President Bush's environmental priorities have spared several agencies from the deep cuts often proposed by Mr. Reagan (and repeatedly rejected by Congress). The doubling of climate-related research by the National Oceanic and Atmospheric Administration (NOAA) kept the agency's total request close to current levels. Climate studies also contributed to the proposed 10.6 percent increase for the Environmental Protection Agency's (EPA) R&D programs. Interest in agricultural productivity helped push the request for the Department of Agriculture (USDA) up 3.4 percent. USGS would enjoy close to a 2 percent increase in FY 1991, primarily for its water quality assessments.

On the technology side, funding for the National Institute of Standards and Technology (NIST) would go up by 17.5 percent, compared to FY 1990. The President has proposed a 2 percent increase in the Department of Education's R&D budget. The only major agency being cut by the Bush Administration in the Bureau of Mines, which would see funding fall by 22.6 percent.

Table I-8 shows how much each of the major agencies would devote to basic research. The major contributors to the $967 million increase proposed for basic research are HHS (29 percent), NASA (23 percent), NSF (21 percent), and DOE (15 percent). As was true last year, EPA would expand its R&D at the fastest pace, with a 29 percent increase proposed for FY 1991. See Chapter 2 for further details on basic research funding estimates.

C. Prospects for R&D in the FY 1991 Budget

Over the past decade, Congress has consistently increased funding for federal R&D. The changing global political and economic outlook makes continued support for R&D likely. The President justified many of his R&D initiatives on the basis of their contribution to the nation's future.

Priority programs were presented thematically in the FY 1991 budget. To expand the "human frontier," the President advocates higher spending for space exploration (e.g., the space station and lunar/Mars exploration), biotechnology (e.g., the human genome project), and high energy physics (e.g., the SSC). To achieve leadership in global change research, the President proposes funding for the Earth Orbiting System and related R&D at other agencies. To protect national security, the Administration seeks higher funding for SDI.

Congressional action on these initiatives, on the other hand, will be piecemeal rather than thematic. By necessity, the President's blueprint for expanding R&D will be parceled out to numerous congressional committees. They, in turn, will make decisions by broad categories, and then by agency.

R&D programs will have to compete for funding along with the other programs under each committee's jurisdiction. In the last few years, R&D has fared well in this competitive environment, receiving better than average increases, especially in the nondefense area. Whether this trend will continue is anyone's guess.

One factor that may either help or hurt R&D funding is the preponderance of "big science" projects. Increases may be inevitable for projects underway. Now that Congress has voted to proceed with the space station and SSC, spending can be expected to rise as they begin construction.

Funding is more precarious for projects that have yet to get the green light. For example, the goal of the Earth Orbiting System (EOS) enjoys widespread support, but its ultimate price tag of $17 billion may dampen congressional enthusiasm. Regardless of their status, Congress may tinker with project budgets, forcing the agencies to revise plans and timetables.

NASA's ambitious agenda will put all of these issues to the test. The agency has proposed several new and large initiatives, and must compete for funds with NSF, EPA, and other agencies funded by the Veterans Affairs, Housing and Urban Development and Independent Agencies appropriation.

Perhaps the biggest cloud in the funding horizon is the prospect of across-the-board cuts. If either the White House or the Congress tries to achieve significant savings through sequestration, R&D programs would be among the hardest hit. The R&D community can only hope that fiscal policy will be guided by national priorities instead of budget mechanics.

Chapter 2

Special Analyses

American Association for the Advancement of Science

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This chapter provides brief overviews of several important areas of R&D trends. These include federal funding of basic research, federal support for R&D at colleges and universities, a snapshot of the major national performers and funders of R&D, and state support for R&D. The tables supporting this discussion are found at the end of Part I. Trends in industrial R&D, which formerly were covered briefly in this chapter, are now the subject of a separate new chapter following this one.

A. Basic Research

In the FY 1991 budget the Bush Administration provides both rhetorical and budgetary support for basic research and the role it plays in national R&D and economic affairs. The budget itself contains several phrases stressing the importance of federal support for basic research, and OSTP Director D. Allan Bromley -- in his first appearance before the House Committee on Science, Space, and Technology following the budget's release -- devoted a significant piece of his prepared testimony to these issues.

Table I-8 shows federal support for basic research by agency, with FY 1982 figures shown as a comparison point. It should be noted that the figures for basic research shown in this table are not actually direct budget proposals, but rather are estimates of basic research funding derived from proposed budget data. Agencies present their requests in programmatic terms, and then estimate the amounts that would be spent in different types of R&D based on those requests. Furthermore, interpretations of the definition of basic research are not uniform across agencies, and each agency makes its own distinctions as to type of R&D and estimated spending for each. Consequently, the data reported here are imprecise although generally suggestive in the aggregate.

Support for basic research in FY 1991 would increase from $11.4 billion to roughly $12.4 billion, a $1 billion increase that amounts to about 8.5 percent in current dollars and 4.1 percent in constant dollars (1982 base). These rates of increase are somewhat higher than those for R&D overall (6.7 percent in current dollars and 2.3 percent in constant dollars).

Basic research has grown in both absolute and relative terms in recent years. The estimates for FY 1991 are nearly 64 percent higher than in FY 1982 after correcting for inflation -- an average real growth rate of not quite 6 percent per year compounded. Further, basic research has also grown over the years in its proportion of total federal R&D support, from 10.5 percent in FY 1967 to between 15 and 17 percent in the past few years. FY 1991's figures represent 17.4 percent of total federal R&D (see Table I-5).

As for comparisons of defense and nondefense support, in the past few years roughly 90 percent of federally supported basic research has been nondefense rather than defense-oriented, as shown in Table I-6. For FY 1991 this figure would be 92 percent nondefense. Defense basic research for FY 1991 continues its recent pattern of very slow or no growth. Although it is expected to grow in FY 1991 by about $55 million (an increase of 5.8 percent in current dollars and 1.6 percent in constant dollars), its growth over the past two years (since FY 1989) has been only about 3 percent in current dollars, which translates into a decrease in actual spending power of at least 6 percent. By contrast, nondefense basic research in FY 1991 would increase by 8.7 percent over FY 1990 to nearly $11.4 billion, representing real growth of 4.1 percent. The contrast is even more marked over the past two years, with nondefense basic research funding increasing 17.8 percent since FY 1989 (or a real growth of about 9 percent).

Turning to the agencies (Table I-8), the pattern is a bit more consistently positive in FY 1991 than in last year's proposed budget, with fewer decreases expected for specific agencies. NIH continues as the largest single federal supporter of basic research by a wide margin. However, its basic research funding in FY 1991 would increase by only 5.6 percent in current dollars (1.3 percent in constant dollars), which is below the overall rate of increase for basic research. Its projected total, nearly $4.3 billion, would represent 34.7 percent of all federally supported basic research, down slightly from the past two years.

Agencies receiving significant increases in basic research include, among the larger R&D agencies, NASA and NSF, which would grow by about 14 percent and 12 percent respectively, in current dollars. However, since both of those agencies are handled within the same congressional appropriations subcommittees, it will be difficult for them both to achieve the proposed levels under current budgetary constraints. Among the mid-size to smaller R&D agencies, those slated for sizable increases include the Environmental Protection Agency (29 percent in current dollars), the Smithsonian Institution (nearly 14 percent), and the Commerce Department (just over 12 percent).

The other significant players in the federal basic research support game are the Departments of Energy, Agriculture, and Interior. DOE would receive a slightly greater than average increase (nearly 10 percent in current dollars, about 5 percent in constant dollars). The USDA would get a slightly smaller than average increase (just under 8 percent in current dollars, nearly 4 percent in constant dollars). And Interior's basic research funds would decline by over 5 percent in current dollars and by 9 percent in constant dollars.

Details regarding the specific effects of these trends within each of the agencies can be found in the relevant chapters in Parts II and III of this book.

B. Colleges and Universities

The data on expected federal support for R&D in colleges and universities are shown in Table I-9. In this area, too, the picture is a bit more positive in FY 1991 than it was in last year's proposed budget. We should emphasize -- as we did for basic research above -- that these data do not represent direct programmatic decisions, but are after-the-fact estimates of how much funding is likely to go to colleges and universities under program levels contained in the budget request.

Overall the total of federal R&D support to colleges and universities is expected to increase somewhat by 5.3 percent to about $9.5 billion. However, most of this increase in current dollars would be offset by inflation, leaving real growth of only 1 percent. Real growth between FY 1989 and FY 1991 would be negligible (0.3 percent), under the proposed budget.

The agencies fall into three fairly distinct tiers, in terms of their amount of support for R&D in colleges and universities. Within the top tier, NSF would enjoy the largest increase of such funds under the proposed budget, with an increase of $162 million or over 12 percent in current dollars (7.7 percent in constant dollars). NIH (and its parent department, Health and Human Services) would receive a more modest increase, around 5 percent (about the average for all federal agencies), but NIH would still furnish 45.5 percent of all federal funds going for R&D in colleges and universities. The Defense Department's support in this area would remain essentially static in current dollars, which would amount to a decrease of nearly 4 percent in constant dollars.

Within the second tier of agencies, NASA's support would increase by $40 million, or about 8 percent in current dollars (just under 4 percent in constant dollars). The USDA would receive a modest increase (4.6 percent), which would just barely offset the effects of inflation. DOE's support for R&D at colleges and universities is expected to decline by 3.5 percent in current dollars, by over 7 percent in constant dollars.

Below these two tiers are several other agencies which present a mixed picture in terms of R&D support in colleges and universities, ranging from an increase of nearly 26 percent in the Commerce Department, to a decrease of 14 percent at the Agency for International Development.

C. National Patterns of R&D

Table I-10 shows the national patterns of R&D spending estimated by NSF for calendar year 1990, arraying sources of funds against R&D performers. NSF estimates that total national spending for R&D in 1990 will be $149.7 billion, an increase of 2.5 percent in constant dollars over the two-year period 1988-1990.

Federal spending is expected to account for $69.2 billion, or 46.2 percent of national R&D spending. Its growth rate of 3.6 percent over the two-year period is greater than the overall national figure only because the latter was dragged down by the virtually static totals for industrial R&D over that time. Industry is expected to spend nearly $74 billion, or 49.4 percent of national totals. Funding of R&D by (a) colleges and universities and (b) nonprofit organizations is still relatively small (2.9 percent and 1.5 percent of total national R&D spending, respectively). However, these were the fastest-growing segments in the past two years (15 percent and 14.7 percent growth, respectively, in constant dollars).

Colleges and universities are expected to perform about $15.8 billion of the nation's R&D in 1990, or about 10.6 percent of total national R&D spending. About 58 percent of those funds are expected to come from the federal government, with another 27 percent supported by colleges and universities themselves. Industrial support for R&D performed by colleges and universities -- the subject of much attention for nearly a decade -- continues to grow at a substantial pace, 18.5 percent in constant dollars over the past two years. It is expected to total $1.15 billion in 1990. However, it is still the smallest source of R&D funds for colleges and universities (tied with nonprofit institutions). This figure represents 1.6 percent of all R&D supported by industry, up slightly from 1.4 percent last year.

D. State Support for R&D

Long regarded as minor players on the national science and technology stage, state governments have begun to come into their own in the 1980s. Economic dislocations in states dependent on traditional manufacturing industries and on energy resource extraction led some state governments to look for new models of economic development in the early 1980s. The oft-told tales of science- and technology-based wealth and job creation along Boston's Route 128 corridor and in Silicon Valley helped orient these models toward the strengthening of academic-industry ties, the encouragement of high tech entrepreneurship, and the support of the kind of commercially-oriented applied research which the federal government began to cut back in 1981.

Although multi-million dollar state enterprises like Pennsylvania's Ben Franklin Partnership and Ohio's Thomas Edison Program have achieved some national visibility in recent years, hard data on R&D expenditures by state governments has lagged behind. NSF gathered data on R&D expenditures by state and local governments episodically in the 1960s and 1970s, but the amounts being spent by the states were modest in relation to the cost of NSF's surveys and the Foundation dropped the enterprise after 1977. [For a discussion of state S&T activities incorporating some of these data, see Willis H. Shapley et al., Research & Development: AAAS Report V (AAAS, 1980).]

With the recent renaissance in state-funded S&T activities, the demand for reliable information on its scope has grown and NSF has recently conducted a pilot study and another survey. The preliminary results are used in a short section in Science & Engineering Indicators - 1989, published in February 1990. A more complete report is expected from NSF's Division of Science Resources Studies later in the year.

The NSF data are shown in Table I-14. These data, which are adapted from Appendix Table 4-27 in S&EI-89 show, as expected, substantial real growth in state R&D expenditures over the 1977-1988 period. Total state government expenditures for R&D increased 115 percent in real terms (above the rate of inflation) during this period -- an average real growth rate of about 7 percent per year compounded. In current dollars, the fifty states spent nearly $800 million on R&D in 1988, compared to less than $200 million in 1977.

Some of the largest increases have been in states whose R&D programs are in the vanguard of such activities -- Ohio (up 205 percent in constant dollars), Pennsylvania (up 243 percent), and New Jersey (up 462 percent). But New Mexico has also expanded its R&D funding by a factor of seven (to $34 million) and Maryland is reported to have increased its spending nearly twelve-fold (in constant dollars) and is now second to New York among the states (with 1988 expenditures of $172 million). Other states, including Arizona, Louisiana, and Oregon spent less in real terms on R&D in 1988 that they did in 1977. The implications of these changes are beginning to be felt in the research community and are certain to be the subject of much discussion and policy debate over the coming years.

As was the case in 1977, certain eccentricities in how different states classify and report R&D and how they classify research institutions may have influenced these figures, making some of information difficult to interpret. Also worth noting is the fact that these NSF figures do not include either directly-appropriated state university funds devoted to research or state-funded S&T activities (such as technology transfer and technology-based business development) that are not considered R&D, so overall state spending on science and technology is likely to be considerably higher.

Chapter 3

R&D in Industry

Industrial Research Institute

Lee W. Rivers

THE SITUATION

America's industrial R&D sector is under siege. The challenge to produce new and improved products and services for the global marketplace--faster and better than international competition--has never been greater. Resources to fight the battle have never been more constrained.

Even though U.S. firms are expected to spend more than $72 billion for R&D in 1990, up from $69 billion in 1989, the trends in rate of growth in R&D spending by the private sector continue to show that U.S. industry lags its international competitors. Since 1982, R&D spending in Japan's industrial sector has grown about 60 percent, compared to less than 20 percent for U.S. industry. This trend is likely to continue. A recent poll of Japanese high tech corporations indicated that 66.7 percent expect to "strengthen" their R&D activity in the future, whereas U.S. industrial corporations recently surveyed by the Industrial Research Institute* indicate that only 37 percent expect to increase R&D spending "slightly more," and only 3 percent "significantly more."

To compete effectively for global market share, U.S. industry's R&D dollars are being focused more on product and process development and improvement and away from directed basic research. (Industry, historically, has done very little undirected basic research.) This trend does serve U.S. industry's near-term needs but bodes ill for the longer term. Industry's dwindling longer-term R&D investment in directed basic research must be leveraged by collaborating effectively with other firms, universities, and federal government laboratories. A healthy, growing trend in this direction is developing. Such collaboration can offset the loss of internal funds needed to support both directed basic research and the development of critical generic technologies. In short, the use of "other people's technology" (OPT), whenever and wherever possible, is becoming more and more important.

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* "Industrial Research Institute's Annual R&D Trends Survey." RESEARCH·TECHNOLOGY MANAGEMENT, January-February 1990, pp. 14-16.

A major macroeconomic factor negatively impacting U.S. industrial R&D is this nation's high cost of capital (two to three times that of Japan). R&D spending is affected because the acceptable payback period for investments in R&D facilities and new production-line equipment is severely shortened when capital costs are high. We do not have patient money in the United States. The Japanese do.

Thus, despite our expanding economy (eighth consecutive year), U.S. R&D spending increases in 1990 in most industrial sectors will not exceed inflation. At a time when the importance of technological innovation to the future standard of living of all Americans has never been greater, America's industrial R&D leaders are implementing creative new R&D strategies.

R&D Strategies

To cope with today's "realities" and still survive, grow, and prosper, America's industrial R&D leaders are using multiple strategies, among which are the following:

- Leverage R&D dollars through multiple collaborations with other firms, universities, and federal laboratories.
- Shorten innovation cycle-time through "team" efforts within the company (concurrent, not sequential development).
- Focus limited resources on core technologies.
- Eliminate marginal product lines and related R&D activities.

- Upgrade professional staff skills through continuous training and learning experiences.
- Search worldwide for applicable science and technology.
- Invest in foreign research facilities and personnel.
- Tailor products and services to the specific needs of national markets.
- Incrementally improve products and processes.
- Integrate technology management into corporate strategy.
- Communicate more effectively with local, state, and federal governments.
- Support reform of U.S. education at all levels.
- Prepare for the impact of the technology challenge of Europe 1992 and beyond.
- Assist suppliers and small businesses in their efforts to remain technologically competitive.
- Think globally; act locally.

THE 1990 I.R.I. SURVEY

I.R.I.'s sixth annual survey of industrial research trends was sent to 253 member companies; 119 replied (a 47 percent response). Respondents were asked to estimate the relative change in levels between 1989 and 1990 in the following categories: Expenditures/Effort Allocation/ Personnel Trends/Other Trends.

As in previous years, a scale of 1-5 was used:

1 = "significantly less" (-5 percent or less)
2 = "slightly less" (0 to -5 percent)
3 = "approximately the same" (1 to 5 percent more)
4 = "slightly more" (6 to 15 percent)
5 = "significantly more" (>15 percent)

Survey Highlights

Highlights from the 1990 survey are enlightening:

- As the decline in U.S. competitive position and the potential contribution of technology to the reversal of present trends become increasingly familiar corporate concerns, directors of R&D are feeling the heat. For the sixth straight year, almost half of the respondents to the I.R.I. trends survey expect increased top management attention to R&D during the next 12 months. However, increased interest from top management does not necessarily mean corresponding increases in funding, and survey participatants are becoming less optimistic about the prospects for overall funding growth.

- Continuing competitive pressure on the business brings with it increasing demands on R&D resources. In 1990, for example, 31 percent of respondents expect to need more resources for new business projects, and 33 percent expect to spend more on joint venture activity. More ominously, 38 percent of participants expect to see increases in R&D expenditures to meet government legislation and standards.

- Faced with more management attention and the prospect of low growth in expenditures for R&D in 1990, as well as the need to provide more funding for business development, joint ventures, and government regulation, what are R&D directors going to squeeze? The survey suggests that overall funding of university R&D is unlikely to grow and is under increasing scrutiny. About twice as many companies expect to reduce university support in 1990 as in last year's survey. In addition, there are a few cases where capital spending for R&D may be curtailed in 1990.

Significant Survey Findings

1. Top Management Attention - Over 46 percent of respondents expected to see top management attention to research on longer-term strategic issues increase by more than 5 percent in 1990.

In the 1989 survey, 49.9 percent made this prediction. Even more participants expect top management's attention to development to increase by more than 5 percent; 52 percent in 1990, 51 percent in 1989. Data from all previous I.R.I. surveys show that at least 43 percent of respondents have made predictions of increased management attention every year since 1985, suggesting a sustained buildup of top management interest during this period.

2. Total R&D Expenditures - Although the present estimate for R&D expenditures is mildly optimistic on average, in that 33.6 percent of respondents project an increase in 1990 and only 17 percent project a decline, the overall trend is not encouraging. The fraction of respondents projecting total expenditures for R&D to grow by more than 5 percent has declined steadily, from 44 percent in 1985 to 35.5 percent in 1989.

3. Manpower Levels - The related question on manpower levels shows the same trend. For 1990, an increase is projected by 26.1 percent of respondents, compared with a decrease by 20.1 percent. However, this represents a deceleration in staffing buildup, as 36.1 percent were expecting increases in 1989.

4. Response to Legislation - The survey shows a discouraging rise in the number of respondents predicting the need for more R&D in response to legislation. In 1989, this was 28.2 percent of respondents; in the 1990 survey, it is 38.1 percent.

5. Alliances and Joint Ventures - In the 1988 survey, when the question was first introduced, 52 percent anticipated greater "participation" in joint ventures. By 1989, this had dropped to 40 percent, and in the current survey only 33 percent expect greater participation in 1990. Even though overall funding for joint ventures is expected to grow next year, the decline over the last three years in the number of respondents anticipating growth has been dramatic.

6. Distribution of R&D Costs - No major changes are predicted for the level of support of basic research or existing business, but an increase in spending for new business projects is likely, as 30.8 percent predict greater spending and only 16.3 percent, less. However, this projection is markedly down from last year's survey when 43.2 percent anticipated growth in funding for new business projects.

7. Funding University R&D - The survey suggests that some respondents are planning to cut the funding of university R&D. For 1990, 14.5 percent of respondents anticipate spending "slightly less," and 6 percent "significantly less" on university R&D. The situation appears to be changing for the worse, as the corresponding numbers from the 1989 survey are 8.9 percent and 1.5 percent.

8. Other Trends - For the total sample, no significant changes are anticipated in capital expenditures as a percent of sales or budget, and the operational costs per R&D professional are expected to increase only modestly from $155,000 to $160,000. The industry comparison breaks down into two groups: Pharmaceuticals and the rest. Capital expenditures for pharmaceutical companies for 1989 and 1990 are 20 percent and 18 percent of R&D budget, compared with 13 percent and 14 percent for the total sample. For the same years, R&D expenditures for pharmaceuticals are 10 percent of sales compared with 3.4 and 3.3 percent of sales for the total survey.

Results of the 1990 Survey are shown in the tables that follow:

Table 1 - "Forecast of 1990 Trends by Industry"
Table 2 - "Survey Questionnaire Results"

Survey Questionnaire Results

Expected Changes in 1990 Compared with 1989 Experience	**Relative Change (no. of responses)**						
	NA	**1**	**2**	**3**	**4**	**5**	**NR**
Expenditures							
1. Total R&D expenditures	0	8	11	60	37	3	0
2. Ratio of direct salaries and wages to other direct R&D costs	1	2	13	88	14	1	0
3. Capital spending for R&D operations	0	13	13	66	19	8	0
4. Subcontracting R&D to outside commercial organizations	8	2	13	68	22	2	4
5. Grants, contracts, etc. for university R&D	2	7	17	68	24	1	0
Effort Allocation							
6. Relative distribution of R&D costs:							
a. Support of existing business	0	3	8	86	20	2	0
b. Directed basic research*	7	8	14	70	17	2	1
c. New-business projects	2	5	14	62	33	3	0
7. Ratio of non-centralized (e.g., divisional) to centralized corporate R&D efforts	14	2	15	67	17	4	0
8. Outside-customer technical-service efforts relative to total R&D (in time or dollars)	9	2	10	83	13	1	1
9. R&D efforts in response to existing or proposed legislation, standards, or other governmental rules (in time or dollars)	5	4	7	59	39	4	1
Personnel Trends							
10. R&D professional manpower level	0	6	18	64	29	2	0
11. Hiring new graduates	5	8	13	67	25	0	0
Other Trends							
12. Top management attention to ***Research*** on longer term or strategic issues	0	3	10	51	49	6	0
13. Top management attention to ***Development***	0	0	5	52	53	9	0
14. Participation in consortia for precompetitive university research	16	3	11	66	19	1	3
15. Participation in alliances and joint ventures for R&D	7	3	4	68	32	5	0
16. Licensing technology from others (dollar volume)	5	2	4	88	14	1	5
17. Licensing technology to others (dollar volume)	9	2	2	82	18	2	4
18. Extent of government financial support of R&D	38	2	8	47	10	3	11
19. Contacts with Federal Laboratories	23	1	3	65	20	1	6
20. Overhead costs	1	3	22	76	15	2	0

Quantitative Data

21. What is your capital expenditure for R&D as a percent of your R&D budget?
1988: 13%; 1989: 13%; 1990: 14%

22. R&D expenditures as percent of sales: 1989: 3.4%; anticipated for 1990: 3.3%

23. R&D professionals as a percent of total R&D personnel: 1989: 55%; anticipated for 1990: 55%

24. Operational costs per R&D professional:** 1989 $155,000; estimate for 1990: $160,000

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* Research whose outcome may be unknown at the time the work is undertaken but where there's a reasonable expectation that findings will be valuable to the supporting organization.

** Refers to the actual cost of operating the laboratory. Numerator consists of such costs as salaries (professional and nonprofessional), fringe benefits, travel, training, supplies, secretarial, managerial, analytical and testing services in-house and outside, utilities, taxes, and depreciation. Denominator includes total number of technical professionals at the laboratory, whether in technical or managerial activities.

Chapter 4

Science, Mathematics, and Technology Education and Human Resources in the FY 1991 Budget

American Association for the Advancement of Science

Gerald Kulm, Shirley M. Malcom, Barbara E. Lovitts

Introductory Note

Recent national concern about the state of education in general, and science, mathematics, and technology education in particular, has prompted the inclusion of a chapter on science, mathematics, and technology (SMT) education and human resources in this volume. Fourteen federal departments and agencies were queried about their SMT education, training, and human resources efforts and associated budgets; relevant programs were found in ten. Moving across the departments and agencies in search of education and human resources dollars, the scattered, fragmented, and uncoordinated nature of the federal investment in SMT education is immediately obvious. In some agencies the dollars are hidden in noneducation line items; in others they appear in open grant competitions; and in the Department of Education, the precollege dollars pass through to states and localities as block grants, mainly not identified by subject matter. Consequently, this analysis is based on a less-than-perfect inventory of federally sponsored SMT education programs. Furthermore, despite this chapter's discussion of programs by educational level, the lines that divide the levels for many programs are not straightforward. Some programs may cover one or more educational levels; for example, high school and college. The dollar figures presented herein, therefore, represent a conservative estimate of the federal support of SMT education.

Highlights

- Overall funding for elementary and secondary SMT education in FY 1991 is greater than $466.6 million, up more than 27 percent over FY 1990. (This does not include approximately $1,351.2 million in Chapter 1 and Chapter 2 block grants that go to SMT education.)

- More than $452 million is requested for undergraduate SMT education in FY 1991, a 23 percent increase over FY 1990.

- Graduate education in SMT will receive more than $754.3 million in FY 1991, or a decrease of 11 percent over FY 1990, which is accounted for by a 50 percent decrease in health education loans. Holding the health education loans constant, SMT funds for graduate education increase by 25 percent.

- In FY 1991, programs targeted at underrepresented groups -- minorities, women, and the disabled -- will receive over $355.8 million with $36.5 million for precollege programs, $236.4 million for undergraduate programs, and $82.9 million for graduate programs, an overall increase of over 30 percent.

One approach to getting a general sense of federal support of SMT education is to look at the National Science Foundation (NSF) budget, especially the budget of the Directorate for Science and Engineering Education (SEE). Another barometer of the Administration's support is the Department of Education's (ED) Dwight D. Eisenhower mathematics and science program, which provides block grants to states for training mathematics and science teachers. The 23 percent increase in the NSF-SEE budget and the nearly 70 percent increase in the Eisenhower program indicate good news for SMT education in FY 1991.

Of course, percentages are only relative to the previous year's base and to needs. The NSF-SEE budget of $251 million is still only about half that recommended by recent reports. And the Eisenhower program, at $230 million, will receive about half of the amount originally requested in the legislation under the 1984 Education for

Economic Security Act (ESSA). By the time these grants are distributed to some 15,000 school districts, the money is still spread fairly thin.

On the other hand, these two programs are not the only ones in NSF or ED that support SMT education. Furthermore, almost every federal agency has programs that provide support for SMT education at some level, from grade school to graduate school and beyond.

Table 1. Support for Science, Mathematics, and Technology Education at the National Science Foundation (in millions)

	FY 1989	FY 1990	FY 1991
Science and Engineering Directorate			
Precollege			
Young Scholars	$ 7.0	$ 7.0	$ 7.0
Networks	9.0	16.0	23.0
Teacher Preparation and Enhancement	52.8	62.1	63.7
Materials, Research and Informal Education	23.0	26.0	36.0
Presidential Teaching Awards	1.8	2.9	2.9
Studies and Analysis	4.5	4.4	5.0
Minority Career Access	5.0	11.3	15.0
Undergraduate			
Instrumentation & Lab	16.0	15.8	23.0
Course and Curriculum	4.0	4.0	8.0
Faculty Enhancement	3.0	2.9	4.0
Graduate			
Fellowships	21.6	25.4	30.5
Graduate Researchers	5.0	6.5	6.9
Minority Graduate Fellowships	2.4	4.5	5.4
Research & Related Activities			
Undergraduate			
Student Programs		29.6	38.9
Faculty Enhancement		19.3	20.4
Instrumentation & Lab		22.3	26.3
Course and Curriculum		16.3	35.5
Other		3.0	13.2

Forecast of 1990 Trends by Industry

	R&D as % of Sales		Capital Expenditures for R&D as % of Budget			R&D Professionals as % of Total R&D Personnel		Operational Costs of R&D Professionals ($000)	
	1989	1990	1988	1989	1990	1989	1990	1989	1990
Chemicals & Plastics (14 companies)	3	3	11	14	13	53	53	172	179
Food, Tobacco & Kindred Products (11 companies)	1	1	12	12	11	65	66	135	141
Petroleum & Related Industries (11 companies)	1	1	11	11	14	55	55	160	163
Primary Metal Industries (9 companies)	1	1	14	14	14	47	47	170	173
Pharmaceuticals & Personal Care Products (8 companies)	10	10	15	20	18	54	55	149	157
Electrical Machinery, Equipment & Supplies (7 companies)	4	4	12	11	11	45	45	197	198
Other (31 companies)	5	5	12	12	14	59	59	153	157

National Science Foundation (NSF)

NSF's total FY 1991 request of $463 million for education and human resources represents a 30 percent increase over the FY 1990 budget request. Of this request, significant funds are being provided by the individual research directorates for education-related activities, especially at the undergraduate level. This trend is reflected in the 48 percent jump to $134 million for undergraduate programs Foundation-wide. The graduate programs will receive a 29 percent increase, while precollege education receives the smallest increase, rising 18 percent to $165 million.

In the precollege component of the SEE Directorate, teacher preparation and enhancement continues to receive the largest share of the pie, but the total request of $63.7 million is only a 2.5 percent increase over FY 1990. The largest increase (38 percent for a total of $36 million) for SEE precollege programs is for materials development, which includes funds to initiate special grants for middle school mathematics materials using the scientist/educator/publisher model.

NSF supports a large array of programs for underrepresented groups - minorities, women, and people with disabilities. These programs will receive $94 million, a 49 percent increase over FY 1990. Most of this increase is found in the budgets of the research directorates and includes a new program of faculty awards for 100 outstanding women as well as grants to 10 institutions to develop programs to encourage minority students to pursue graduate studies.

Undergraduate programs in SEE are slated for the largest increase, rising to $50 million - a 47 percent hike over FY 1990. Together with graduate programs, these activities represent about one-third of the directorate's budget. A similar percentage increase in the research directorates brings the NSF support of undergraduate education to $134 million, reflecting an effort to reform the curriculum and improve facilities and teaching in the nation's colleges and universities.

Table 2. Support for Science, Mathematics, and Technology Education at the Department of Education (in millions)

	FY 1989	FY 1990	FY 1991
Science, Mathematics, and Technology			
Elementary and Secondary			
Dwight D. Eisenhower Grants	$ 128.4	$ 132.8	$ 230.0
Center for Mathematics Education	0.5	0.5	0
Center for Science Education	0.5	0.5	0
Educational Technology Center	1.0	1.0	1.0
Star Schools	14.4	14.8	0
ERIC Science, Math, Environment	0.3	0.3	0.3
Postsecondary			
Minority Science Improvement	5.3	5.5	5.6
National Science Scholars	-	-	5.0
Other Estimated Support*			
Elementary and Secondary			
Chapter 1: Grants to LEAs	1006.5	1148.3	1239.7
Chapter 2: Block Grants to LEAs	107.9	107.3	111.5
Magnet Schools for Desegregation	28.4	28.3	28.3
Magnet Schools of Excellence	-	12.5	25.0
Indian Education Grants	20.6	29.4	30.3
National Assessment of Educational Progress	2.4	4.3	5.5
Education R&D Centers	1.4	1.5	1.6
Regional Educational Labs	0.9	0.9	1.0
National Diffusion Network	2.1	2.2	2.2
Fund for Innovation in Education	5.9	1.0	1.0
Fund for the Improvement and Reform of Schools and Teaching	0.3	0.3	0.3
Javits Gifted and Talented	2.0	2.2	2.2
Postsecondary			
Fund for the Improvement of Postsecondary Education	2.7	2.7	2.7
Graduate Assistance in Areas of National Need	3.2	3.9	6.4
Minority Participation in Graduate Ed	0.8	0.8	1.5

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* Amounts are estimates of the portion of the programs that directly support science, mathematics, or technology education.

Department of Education (ED)

The brightest point in ED's FY 1991 budget for SMT education is the $230 million request for the Dwight D. Eisenhower block grant program, a 70 percent increase. States and local school districts depend on this program to update and retrain their science and mathematics teachers. For several years, Congress has added money to the Administration's request. This is the first year ED is asking for a significant increase on its own.

The small programs at ED that support SMT education centers are slated for level funding, and in some cases, are being phased out in favor of the traditional R&D centers which are not content specific. One new initiative is a National Science Scholars program, which has a request of $5 million to provide college scholarships for top students in each state.

The bulk of ED's funding is in Chapter 1 and Chapter 2 block grants to local education agencies to supplement the education of disadvantaged students. Recent analyses of these programs indicate that about 25 percent of their funds are spent on SMT education, making the Chapter 1 and Chapter 2 block grants the single largest source of federal support for SMT education. The FY 1991 ED budget includes an estimated $1.35 billion for these programs, up about 8 percent over FY 1990.

Magnet schools and Indian Education programs also allocate significant portions of their grants to support SMT education activities. An estimated $53 million of the magnet schools request will support SMT education, a jump of 30 percent over FY 1990. This is due largely to the Administration's focus on magnet schools as a means of promoting educational choice not tied to desegregation efforts. About $30 million of the Indian Education grants will be spent on science and mathematics, the same as in FY 1990.

The Administration has again zeroed-out funding for Star Schools, a program to develop telecommunications centers to offer advanced coursework in subject areas including mathematics, science, and technology. Despite the Administration's persistent efforts to cut the program, Congress, each year, has responded by appropriating significant funds -- $15 million in FY 1990. It is likely that this trend will continue.

ED's Office of Educational Research and Improvement (OERI) funds most of the research and development activities focused directly on SMT education. The National Assessment of Educational Progress (NAEP) budget will increase 10 percent to $18.9 million. An estimated $5.5 million of the NAEP budget will support SMT activities, including state-by-state mathematics comparisons in grades 4 and 8. Other research support will see small increases, with a promise of a few new R&D centers in the 1991 recompetition. Requests for the Fund for the Improvement and Reform of Schools and Teaching (FIRST) and the Fund for Innovation in Education (FIE) have increased, but these programs have not had a good record in supporting SMT proposals. The recent addition of the Eisenhower national program to the FIRST office will boost that budget and may promote more overall SMT grant activity. The request for the National Diffusion Network, which funds the dissemination of many SMT programs, has a level funding request for FY 1991.

Table 3. Support for Science, Mathematics, and Technology Education in Other Departments and Federal Agencies (in millions)

	FY 1989	FY 1990	FY 1991
DEPARTMENT OF AGRICULTURE			
Precollege	$ 0.2	$ 0.2	$ 0.2
Capacity Building Grants			
Undergraduate Institutions	4.7	11.1	13.0
Underrepresented Institutions	-	155.1	158.5
Graduate Fellowship and Capacity Building Grants	7.6	14.9	19.0
DEPARTMENT OF DEFENSE			
Precollege and Undergraduate			
High School apprentice	1.8		
High School teachers	0.8	1990 and 1991 data is not available	
Summer programs	1.5		
Uninitiates in Engineering	1.4		
Science fairs & symposia	1.0		
Undergraduate Education	1.6		
HBCU/Adopt-a-College	0.2		
Graduate			
Fellowships	303.0	317.0	328.0

Table 3. (Continued)

	FY 1989	FY 1990	FY 1991
DEPARTMENT OF ENERGY			
Precollege			
Student Honors/Faculty Research	$ 1.8	$ 1.8	$ 1.9
High School Teacher Researchers	-	-	1.3
Math Science Teacher Program	-	-	2.0
Inner City/Rural Partnerships	-	-	2.0
Prefreshman Engineering	0.4	0.4	1.4
Museum-based Science Programs	-	-	1.0
Undergraduate			
Summer Faculty/Student Research	9.3	10.1	9.4
Nuclear Engineering Research & Ed	5.9	5.9	0
Minority Honors Training	0.4	0.4	0.4
Minority Institution Assistance	0.7	1.7	1.3
HEALTH AND HUMAN SERVICES			
Graduate			
Health Education Loans	321.0	370.0	185.0
Training Programs	45.3	70.9	66.0
Minority Fellowship Programs	5.4	5.8	4.7
National Health Service Corps	-	-	60.0
NATIONAL INSTITUTES OF HEALTH			
Precollege and Undergraduate			
School Cancer Education	-	2.9	2.9
National Research Service Awards	-	-	35.8
Minority Biomedical Research	-	29.8	32.3
Minority Access to Research Careers and Undergraduate Research Training	-	10.7	13.4
Graduate			
Research Career Program		8.3	8.3
Environmental Health Training		27.1	27.1
Public Information and Outreach			
Heart, Lung, and Blood Institute		48.6	51.3
DEPARTMENT OF INTERIOR			
Precollege	na	0.2	1.1
Undergraduate	na	na	0.5
Visitors Centers and Outreach	na	92.1	95.7
ENVIRONMENTAL PROTECTION AGENCY			
Undergraduate			
Minority Fellowships & Interns	0.3	0.2	0.2
Visiting Scientists & Engineers	0.3	0.4	0.4
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION			
Precollege			
Aerospace Education Services	3.0	2.6	3.9
Innovative Student/Teacher	1.5	1.4	3.2
Undergrduate and Graduate			
Space Grants	1.3	6.8	10.0
HCBU Grants	7.7	8.5	9.1
Other Minority Universities	-	2.0	4.0
Student Researchers Program	2.0	3.2	3.7

Department of Agriculture (USDA)

USDA's activities focus on building the capacity of colleges and universities to improve teaching and research. The $158 million FY 1991 request for minority institutions, which requires matching non-federal funds, is in its second year and replaces the Morrill-Nelson grants program which did not require matching funds. Overall, USDA's FY 1991 budget request for education-related programs is $190 million, a modest 5 percent increase over FY 1991.

Department of Defense (DoD)

The bulk of DoD support for SMT education is concentrated at the graduate level. DoD will sponsor over 21,000 graduate fellows, at an estimated cost of $328 million in FY 1991. Other graduate students are supported through research grants to university faculty and to DoD laboratories. Various branches of DoD continue to support about 90 different programs and activities for precollege and undergraduate students, with some programs targeted specifically at minorities. At this time, only the FY 1989 figures are available. In FY 1989 more than $10 million was spent for these programs, which probably represents only a portion of the total money spent on precollege and undergraduate SMT education by DoD each year.

Department of Energy (DOE)

Of the noneducation mission-oriented agencies, DOE has taken a lead in promoting, planning, and supporting new initiatives in SMT education. Building on the success of on-going programs for gifted and minority students in its R&D labs, DOE is expanding its support of precollege students and teachers with a budget request of $9.4 million, quadrupling its FY 1990 request. The request includes a $1 million increase for the minority Prefreshman Engineering Program (PREP) — a significant increase over the FY 1990 request of $2.2 million — and $3.25 million for two new teacher education programs. Support for undergraduate education is decreasing from $18 million to $11 million, reflecting the department's shift in emphasis to elementary and secondary school education. In addition, DOE labs are being asked to undertake off-line initiatives and volunteer efforts, especially at the precollege level.

Department of Health and Human Services (HHS)

HHS education programs have traditionally focused on graduate training and career enhancement in health-related professions. Its large loan program is being phased out. In FY 1991, $185 million is requested, which is half of the FY 1990 request. Several other HHS education programs are also being phased out or are requesting level funding or small increases. However, the Health Resource and Services Administration (HRSA) is requesting $107 million for a new Minority Health Initiative program, of which $5 million would go to communities and institutions for recruitment and educational support of health professionals, and $55 million would go for the National Health Services Corps (NHSC) to recruit disadvantaged and minority health professions students to practice in underserved areas.

National Institutes of Health (NIH)

NIH supports an array of educational programs, with the bulk of their funding aimed at the post-doctoral level. The objective of many of NIH's programs is the recruitment and training of minority professionals, from high school through post-doctoral study. The National Service Award program, which supports students at all educational levels, is level funded in FY 1991 at $35.8 million. The Minority Access to Research Careers (MARC) is a similar program, which anticipates a $2.7 million increase to $13.4 million. The Minority Biomedical Research Support (MBRS) program, involving students at institutions with significant minority student enrollments in biomedical research, is requesting an 8.5 percent increase of $2.5 million for a total of $32.3 million dollars in FY 1991.

Department of Interior (DI)

DI is requesting a $7.4 million increase to $98.3 for its education-related activities, with $2.6 million slated to support precollege and undergraduate level earth science education. The bulk of DI's educational efforts are focused on activities at the various parks and interpretive centers, which host 500 million visitors annually. About 80 percent or $95.7 million of the FY 1991 budget request is targeted for these activities, which include working with school children, teachers, and adult education groups.

Environmental Protection Agency (EPA)

EPA receives about $600,000 annually to support undergraduate minority fellowships, internships, and a visiting scientist and engineer program. The latter is an innovative program that provides grants to community groups for community-based environmental and scientific projects and activities, drawing upon retired EPA scientists to serve as speakers and specialists. In FY 1991, EPA's minority institutional assistance program for Historically Black Colleges and Universities (HBCUs) will be broadened to include Hispanic, Native American, and other minority institutions. EPA also supports several precollege and college-level programs with monies that are not part of its line item budget request. In FY 1991, look for the creation of an Office of Education within EPA under the Environmental Education Act (S#1076), which is currently before Congress.

National Aeronautics and Space Administration (NASA)

NASA has been a visible partner in SMT education. NASA has consolidated its precollege programs with its university programs to form an Educational Affairs Program and is asking for total FY 1991 funding of $50 million, of which $34 million is targeted at the elementary through college levels. The precollege request of $7.1 million is nearly double the FY 1990 appropriation and includes significant increases for activities targeted toward underrepresented students and for additional Teacher Resource Centers. The NASA Space Grant program will increase to $10 million from $6.8 million to broaden the base of participating universities.

Table 4. FY 1991 Budget Requests for Underrepresented Groups by Agency (in millions)

Agency	Precollege	Undergraduate	Graduate
USDA	-	158.5	-
DoD		Data not available	
ED	30.3	5.6	6.1
DOE	3.3	1.7	-
HHS	-	-	54.7
DI	-	-	-
EPA	Not line item	0.2	-
NASA	-	14.6	-
NIH	2.9	39.0	6.7
NSF	-	15.0	5.4
Total	36.5	236.4	82.9

SMT Programs for Underrepresented Groups

Much of the interest in supporting SMT education for underrepresented groups appears to draw its energy from two sources: efforts of the Task Force on Women, Minorities, and the Handicapped in Science and Technology and the White House Initiative on Historically Black Colleges and Universities. Increases in targeted precollege programs have been modest ($36.5 million in FY 1991, up 9 percent from FY 1990; not counting ED Chapter 1 and Chapter 2 block grants), despite expert opinion that the overwhelming problem, at least for minority and disabled students, lies at the precollege level. The bulk of the targeted support is found at the college level ($236.4 million in FY 1991 up 6 percent from FY 1990). Much of this funding appears to be targeted at building research capacity and human resources at the HBCUs and other postsecondary institutions serving significant minority populations. What cannot be determined by these figures is the extent to which nontargeted SMT precollege programs impact underrepresented groups, how well precollege general education programs aimed at underrepresented students foster SMT education, or how effectively college-based programs affect the precollege students and/or their teachers.

Human Resources for Science, Mathematics, and Technology

Most of the funding for the SMT human resource base is found largely as support for graduate, post-doctoral, and undergraduate students in the regular R&D budget. However, this support cannot be determined with any degree of consistency across departments and agencies, because it tends to be distributed as budget targets within the research line. Significant line-item funding for human resources does appear within the HHS budget and approximately $70 to $80 million appears to be spread across NSF in human resource targets not specified in Table 1.

The Bottom Line

While SMT-focused departments and agencies provide support for students directly or through supported research, this support occurs only after students have signalled an intention to pursue careers in science or engineering. However, there is less clear and consistent support of activities at the precollege level. Legislative authority for precollege programming does not exist for all departments and agencies despite their dependence on an effective K-12 SMT pipeline. For all the "ownership" by departments and agencies that distributed programming buys at the undergraduate level and beyond, the resulting fragmentation makes it difficult to get a clear picture of the health of the system that is the human infrastructure of science and engineering in the United States.

Overview Tables

Table I-1. Composition of the FY 1991 Budget (outlays in billions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change FY 1990-91
Current Dollars				
National Defense	$303.6	$296.3	$303.3	2.3%
R&D Included	(41.4)	(40.8)	(41.3)	(1.3%)
Payment & Grants*	589.8	636.8	673.0	5.7%
Net Interest	169.1	175.6	173.0	–1.5%
Undistributed Offsetting Receipts	(37.2)	–36.5	–43.6	19.5%
Other Government	117.4	125.0	127.7	2.2%
R&D Included	(21.5)	(23.9)	(27.0)	(13.2%)
TOTAL Outlays	$1,142.6	$1,197.2	$1,233.3	3.0%
R&D Included	(62.9)	(64.7)	(68.3)	(5.6%)
Receipts	$990.7	$1,073.5	$1,170.2	9.0%
Deficit (–) or Surplus	–$152.0	–$123.8	–$63.1	–49.0%
Constant 1982 Dollars				
National Defense	$255.9	$240.5	$235.5	–2.1%
R&D Included	(32.9)	(31.1)	(30.2)	(–2.9%)
Payments & Grants*	452.9	469.6	476.0	1.4%
Net Interest	133.5	133.2	126.0	–5.4%
Undistributed Offsetting Receipts	29.1	27.4	31.4	14.6%
Other Government	93.8	96.2	94.7	–1.6%
R&D Included	(17.1)	(18.2)	(19.7)	(8.6%)
TOTAL Outlays	$907.1	$912.2	$900.8	–1.2%
R&D Included	(50.0)	(49.3)	(49.9)	(1.2%)
Receipts	$786.5	$817.9	$854.7	4.5%
Deficit (–) or Surplus	–$120.6	–$94.3	–$46.1	–51.1%

Source: *Budget of the United States Government, Fiscal Year 1991*
*Payments to individuals and grants-in-aid

Table I-2. Projections Through FY 1995 in the FY1991 Budget (in billions)

	FY 1991 Budget	FY 1992 Projected	FY 1993 Projected	FY 1994 Projected	FY 1995 Projected
Current Dollars					
Outlays:					
National Defense	$303.3	$309.2	$311.9	$315.7	$318.6
R&D included	(41.3)	(42.1)	(42.5)	(43.0)	(43.4)
Payments and Grants	673.0	713.0	756.5	801.0	845.4
Net Interest	173.0	163.5	157.0	147.8	136.1
Undistributed Offsetting Receipts	–43.6	–43.8	–46.2	–46.6	–49.5
Other Government	127.7	129.5	142.6	180.1	226.3
R&D included	(27.0)	(27.4)	(30.1)	(38.0)	(47.8)
TOTAL Outlays	$1,233.3	$1,271.4	$1,321.8	$1,398.0	$1,476.9
Receipts	$1,170.2	$1,246.4	$1,327.6	$1,408.6	$1,486.3
Deficit (–) or Surplus	–$63.1	–$25.1	$5.7	$10.7	$9.4
Constant FY 1982 Dollars					
Outlays:					
National Defense	$235.5	$230.7	$224.0	$219.1	$214.3
R&D included	(30.2)	(29.6)	(28.8)	(28.1)	(27.6)
Payments and Grants	476.0	485.0	495.8	507.5	519.3
Net Interest	126.0	114.5	106.0	96.5	86.2
Undistributed Offsetting Receipts	–31.4	–30.4	–30.9	–30.1	–31.1
Other Government	94.7	92.7	98.4	119.6	145.2
R&D included	(19.4)	(18.9)	(20.1)	(24.6)	(29.9)
TOTAL Outlays	$900.8	$892.5	$893.4	$912.6	$933.9
Receipts	$854.7	$874.9	$897.2	$919.5	$939.8
Deficit (–) or Surplus	–$46.1	–$17.6	$3.9	$7.0	$5.9

Source: Author's estimates based on *Budget of the United States Government, FY 1991*. Constant dollar conversions based on OMB deflators.

Table I-3. Budget Authority, Obligations, and Outlays for R&D, Including Facilities (in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
National Defense R&D				
Budget Authority	$41,579.3	$41,044.1	$42,492.3	3.5%
Obligations	42,626.1	40,933.0	42,364.0	3.5%
Outlays	41,388.6	40,803.7	41,336.8	1.3%
Nondefense R&D				
Budget Authority	22,704.6	25,672.7	28,665.9	11.7%
Obligations	22,593.2	25,861.0	28,544.2	10.4%
Outlays	21,551.0	23,854.8	26,982.1	13.1%
Total R&D				
Budget Authority	64,283.9	66,716.8	71,158.2	6.7%
Obligations	65,219.3	66,794.0	70,908.2	6.2%
Outlays	62,939.6	64,658.5	68,318.9	5.7%
Constant FY 1982 Dollars (budget authority only)				
National Defense R&D	$32,871.6	$31,200.4	$31,000.4	–0.6%
Nondefense R&D	17,720.0	19,263.7	20,642.3	7.2%
TOTAL R&D	$50,591.6	$50,464.1	$51,642.7	2.3%

Source: OMB's data for R&D analysis for FY 1991, and agency justifications. Constant dollar estimates derived from OMB fiscal year deflators for national defense R&D and nondefense R&D.

Table I-4. Major Components of Federal Funding for R&D* (budget authority in billions)

	FY 1967 Actual	FY 1972 Actual	FY 1988 Actual	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget
Current Dollars						
Defense[1]	$8.8	$9.2	$41.0	$41.6	$41.0	$42.5
Nondefense[2]	8.3	7.9	20.1	22.7	25.7	28.7
Space[3]	4.7	2.7	2.8	3.7	4.8	6.3
Health[4]	1.3	2.0	7.4	8.2	8.8	9.2
Energy[5]	0.6	0.6	2.3	2.5	3.0	2.9
General Science[6]	0.5	0.7	2.4	2.7	3.0	3.4
All Other	1.2	1.9	5.1	5.7	6.1	6.9
TOTAL R&D	$17.1	$17.1	$61.0	$64.3	$66.7	$71.2
Constant FY 1982 Dollars						
Defense	$29.0	$22.2	$33.9	$32.9	$31.2	$31.0
Nondefense	24.5	17.6	16.4	17.7	19.3	20.6
Space	13.9	6.0	2.3	2.9	3.6	4.5
Health	3.8	4.4	6.1	6.4	6.6	6.6
Energy	1.8	1.3	1.9	2.0	2.3	2.1
General Science	1.5	1.6	1.9	2.1	2.2	2.4
All Other	3.5	4.2	4.2	4.4	4.6	4.9
TOTAL R&D	$53.5	$39.8	$50.3	$50.6	$50.5	$51.6

Source: Author's estimates based on data from OMB and agency budget justifications. Conversion to constant dollars by authors based on OMB deflators.

*Includes conduct of R&D and R&D facilities.

[1] Includes DOD and defense activities of DOE.

[2] Includes all R&D not in defense.

[3] Reflects totals for NASA R&D less space applications and aeronautics.

[4] includes health research in HHS, VA, Education and EPA. FY 1967 and 1972 based on OMB data for health research in all federal agencies.

[5] Includes NRC, EPA energy research, and DOE less defense activities and general science.

[6] Includes NSF and DOE general science.

Table I-5. R&D by Character of Work (budget authority in billions)

	FY 1967 Actual	FY 1972 Actual	FY 1988 Actual	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget
Current Dollars						
Basic Research	$1.8	$2.2	$9.5	$10.6	$11.4	$12.4
Applied Research	2.9	3.6	9.2	9.8	10.2	10.9
TOTAL Research	$4.7	$5.8	$18.7	$20.4	$21.6	$23.2
Development	11.8	10.7	40.3	41.6	42.1	44.9
TOTAL Conduct of R&D	$16.5	$16.5	$58.9	$62.0	$63.7	$68.1
R&D Facilities	0.6	0.6	2.1	2.3	3.0	3.0
TOTAL R&D	$17.1	$17.1	$61.0	$64.3	$66.7	$71.2
Constant FY 1982 Dollars						
Basic Research	$6.4	$5.5	$7.8	$8.3	$8.6	$8.9
Applied Research	10.4	9.0	7.5	7.7	7.7	7.9
TOTAL Research	$16.8	$14.5	$15.3	$16.0	$16.2	$16.8
Development	42.1	26.8	33.3	32.7	31.9	32.7
TOTAL Conduct of R&D	$58.9	$41.3	$48.6	$48.7	$48.2	$49.5
R&D Facilities	2.1	1.5	1.7	1.8	2.3	2.2
TOTAL R&D	$61.0	$42.8	$50.3	$50.6	$50.5	$51.7

Source: OMB's data for R&D analysis for FY 1991, agency justifications, and National Science Foundation, *Federal Funds*. Conversion to constant dollars by authors based on OMB deflators.

Table I-6. Defense and Nondefense R&D by Character of Work (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91	
				Current $	Constant $
Basic Research					
Defense	$964.7	$939.1	$994.0	5.8%	1.6%
Nondefense	9,653.2	10,457.5	11,369.5	8.7%	4.3%
TOTAL	$10,617.9	$11,396.6	$12,363.5	8.5%	4.1%
Applied Research					
Defense	$2,879.6	$2,809.1	$2,872.2	2.2%	-1.9%
Nondefense	6,931.3	7,386.5	7,978.3	8.0%	3.7%
TOTAL	$9,810.9	$10,195.6	$10,850.5	6.4%	2.1%
Development					
Defense	$36,797.8	$36,128.5	$37,555.2	3.9%	-0.2%
Nondefense	4,760.9	5,976.7	7,350.9	23.0%	18.0%
TOTAL	$41,558.7	$42,105.2	$44,906.1	6.7%	2.3%
Total Conduct of R&D					
Defense	$40,642.1	$39,876.7	$41,421.4	3.9%	-0.3%
Nondefense	21,345.4	23,820.7	26,698.7	12.1%	7.6%
TOTAL	$61,987.5	$63,697.4	$68,120.1	6.9%	2.6%
R&D Facilities					
Defense	$937.2	$1,167.4	$1,070.9	-8.3%	-12.0%
Nondefense	1,359.2	1,852.1	1,967.2	6.2%	1.9%
TOTAL R&D Facilities	$2,296.4	$3,019.5	$3,038.1	0.6%	-3.5%

Table I-6. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91	
				Current $	Constant $
TOTAL R&D					
Defense	$41,579.3	$41,044.1	$42,492.3	3.5%	-0.6%
Nondefense	22,704.6	25,672.7	28,665.9	11.7%	7.2%
TOTAL R&D	$64,283.9	$66,716.8	$71,158.2	6.7%	2.3%

Source: OMB's data for R&D analysis for FY 1991, and agency budget justifications. Constant dollar conversions derived from OMB fiscal year deflators for defense R&D and nondefense R&D.

Table I-13. Industry Spending for R&D by *Business Week* Groupings, 1988 (in millions)

Industry	1988	Percent Change from 1987
Aerospace	$3,918.6	1%
Automotive	9,528.2	12%
Chemicals	4,454.1	10%
Conglomerates	3,163.8	2%
Consumer Products	1,595.3	9%
Containers and Packaging	62.5	3%
Electrical and Electronics	6,107.5	13%
Electrical Products	650.2	2%
Electronics	2,011.5	19%
Instruments	1,379.0	7%
Semiconductors, Components	2,066.8	15%
Food	509.2	3%
Fuel	1,703.8	6%
Health Care	6,620.1	19%
Drugs, Research	4,344.5	19%
Medical Products and Services	2,375.6	18%
Housing and Construction	494.7	0%
Leisure Time Industries	1,620.6	12%
Manufacturing	2,309.6	9%
Metals and Mining	258.4	-2%
Nonbank Financial	92.9	27%
Office Equipment and Computers	13,210.7	18%
Business Machines, Services, and Supplies	234.6	13%
Data Processing	128.1	26%
Computers	9,962.3	16%
Computer Terminals	53.3	32%
Disk and Tape Drives	296.2	24%
Peripherals and Other Devices	1,269.0	14%
Software and Services	652.6	33%
Systems Design	614.6	35%
Paper and Forest Products	421.7	12%
Service Industries	178.3	4%
Telecommunications	3,127.5	6%
TOTAL	$59,377.2	11%

Source: Author's estimates based on "R&D Scoreboard, 1988" reprinted from the June 16, 1989, issue of *Business Week* by special permission, © 1989.

Note: Based on SEC data for companies reporting 1988 sales of $35 million or more, and R&D expenses amounting to at least $1.0 million or at least 1.0 percent of sales.

Table I-14. State R&D Expenditures from State Funds, 1977 and 1988
(in millions of current dollars)

State	1977	1988	Percent Change (Constant Dollars)
Alabama	$0.4	$1.0	50%
Alaska	3.6	6.9	5%
Arizona	0.4	0.7	–14%
Arkansas	0.2	1.0	168%
California	23.7	53.3	24%
Colorado	1.6	1.4	–52%
Connecticut	2.3	8.4	100%
Delaware	0.2	2.5	586%
Florida	7.4	13.7	2%
Georgia	1.3	9.0	296%
Hawaii	2.3	3.0	–28%
Idaho	0.6	1.0	–11%
Illinois	10.6	42.7	123%
Indiana	2.7	8.1	67%
Iowa	1.2	7.8	265%
Kansas	1.0	7.6	326%
Kentucky	5.4	6.7	–32%
Louisiana	4.5	2.8	–65%
Maine	0.7	2.6	111%
Maryland	7.6	172.1	1148%
Massachusetts	1.8	6.0	81%
Michigan	4.8	15.2	75%
Minnesota	3.0	6.2	14%
Mississippi	0.9	2.4	47%
Missouri	0.6	1.0	–17%
Montana	1.8	3.2	–2%
Nebraska	0.3	1.5	225%
Nevada	0.2	1.8	400%
New Hampshire	0.3	0.0	–100%
New Jersey	2.1	21.0	462%
New Mexico	2.4	34.1	690%
New York	64.3	194.3	67%
North Carolina	5.1	10.8	17%
North Dakota	1.1	0.9	–54%
Ohio	5.3	29.4	205%
Oklahoma	0.6	0.6	–48%
Oregon	1.8	2.0	–37%
Pennsylvania	5.7	35.6	243%
Rhode Island	0.5	1.0	15%
South Carolina	2.2	4.6	16%
South Dakota	0.9	1.5	–7%
Tennessee	0.5	2.3	146%
Texas	4.9	11.0	23%
Utah	0.8	1.0	–34%
Vermont	0.1	0.3	66%
Virginia	3.0	10.5	95%
Washington	2.6	12.5	161%
West Virginia	0.2	0.3	42%
Wisconsin	2.3	5.8	157%
Wyoming	0.2	0.3	64%
TOTAL, All States	$197.6	$769.3	115%

Source: National Science Foundation, *Science and Engineering Indicators, 1989*, Appendix Table H-27

Table I-7. R&D in Selected Agencies (budget authority in millions)*

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91	
				Current $	Constant $
Department of Defense	$38,578.2	$37,864.8	$39,171.8	3.5%	–0.7%
Department of Energy–Defense	3,001.1	3,179.3	3,320.5	4.4%	0.2%
(TOTAL Defense)	(41,579.3)	(41,044.1)	(42,492.3)	(3.5%)	(–0.6%)
DOE–General Science	905.2	1,089.5	1,264.1	16.0%	11.3%
DOE–Energy	2,348.8	2,893.6	2,798.1	–3.3%	–7.2%
(TOTAL DOE)	(6,255.1)	(7,162.4)	(7,382.7)	(3.1%)	(–1.1%)
National Aeronautics and Space Administration	5,919.5	7,231.8	9,259.8	28.0%	22.9%
National Science Foundation	1,761.8	1,885.2	2,135.9	13.3%	8.7%
National Institutes of Health	6,821.9	7,216.5	7,560.3	4.8%	0.5%
Other Health and Human Services	1,141.8	1,366.3	1,469.5	7.6%	3.2%
Department of Agriculture	1,139.0	1,215.9	1,257.1	3.4%	–0.8%
Environmental Protection Agency	397.3	424.0	468.8	10.6%	6.1%
Department of Education	147.4	162.0	164.7	1.7%	–2.4%
National Oceanic and Atmospheric Administration	282.8	290.5	287.7	–1.0%	–5.0%
National Institute of Standards and Technology	129.9	134.6	158.1	17.5%	12.7%
Geological Survey	281.2	301.6	306.9	1.8%	–2.3%
Bureau of Mines	97.0	100.4	77.7	–22.6%	–25.7%
All Other	1,331.0	1,360.8	1,457.2	7.1%	2.8%
(TOTAL Nondefense)	(22,704.6)	(25,672.7)	(28,665.9)	(11.7%)	(7.2%)
TOTAL R&D	$64,283.9	$66,716.8	$71,158.2	6.7%	2.3%

Source: OMB's data for R&D analysis for FY 1991, and agency budget justifications.
*Includes conduct of R&D and R&D facilities.

Table I-8. Conduct of Basic Research by Agency in Current Dollars (budget authority in millions)

	FY 1982 Actual	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91	
					Current $	Constant $
Health and Human Services	$1,954.0	$4,412.8	$4,714.3	$4,992.9	5.9%	1.6%
(National Institutes of Health)	(1,841.0)	(3,898.7)	(4,068.0)	(4,294.2)	(5.6%)	(1.3%)
National Science Foundation	913.0	1,562.9	1,651.0	1,853.2	12.2%	7.7%
Defense (military)	696.0	950.7	923.5	977.8	5.9%	1.6%
Energy	779.0	1,382.7	1,512.4	1,658.4	9.7%	5.2%
National Aeronautics & Space Administration	536.0	1,384.5	1,596.3	1,822.5	14.2%	9.6%
Agriculture	334.0	488.9	510.5	551.0	7.9%	3.6%
Interior	74.0	223.6	240.6	227.9	-5.3%	-9.1%
Smithsonian	56.0	82.0	88.0	100.0	13.6%	9.1%
Commerce	17.0	29.8	29.1	32.7	12.4%	7.8%
Veterans Affairs	13.0	16.4	16.2	15.2	-6.2%	-10.0%
Education	16.0	4.0	4.6	5.0	8.7%	4.3%
Environmental Protection Agency	24.0	52.1	76.6	98.8	29.0%	23.8%
Agency for International Development[1]	—	4.8	8.5	6.7	-21.2%	-24.4%
Other	31.0	22.7	25.0	21.4	-14.4%	-17.9%
TOTAL, Basic Research (in current $)	$5,440.0	$10,617.9	$11,396.6	$12,363.5	8.5%	—
TOTAL, Basic Research (in constant FY 1982 $)	($5,440.0)	($8,296.6)	($8,560.7)	($8,912.3)	—	(4.1%)

Source: OMB's data for R&D analysis for FY 1991, and agency budget justifications.

[1] Reported under "Other" in 1982.

Table I-9. Estimated Support for Conduct of R&D at Colleges and Universities in Current Dollars (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91	
				Current $	Constant $
Health and Human Services	$4,583.5	$4,855.4	$5,121.2	5.5%	1.2%
(National Institutes of Health)	(4,008.3)	(4,143.8)	(4,339.0)	(4.7%)	(0.5%)
National Science Foundation	1,260.1	1,323.6	1,485.4	12.2%	7.7%
DOD (military)	1,329.2	1,254.2	1,255.8	0.1%	–3.9%
Agriculture	316.5	331.3	346.6	4.6%	0.4%
Energy	507.1	469.2	452.9	–3.5%	–7.4%
National Aeronautics and Space Administration	433.7	493.0	533.0	8.1%	3.8%
Agency for International Development	57.8	46.7	40.1	–14.1%	–17.6%
Environmental Protection Agency	57.8	63.3	67.1	6.0%	1.7%
Education	105.8	106.8	106.9	0.1%	–3.9%
Interior	38.2	37.7	37.4	–0.8%	–4.8%
Transportation	17.6	23.5	25.4	8.1%	3.7%
Commerce	46.1	39.5	49.6	25.6%	20.5%
Other	20.2	19.2	21.4	11.5%	7.0%
TOTAL (in current $)	$8,773.6	$9,063.4	$9,542.8	5.3%	—
TOTAL (in constant FY 1982 $)	$6,861.1	$6,813.4	$6,884.0	—	1.0%

Source: OMB's data for R&D analysis for FY 1991. Conversion to constant FY 1982 dollars by authors based on OMB deflators.

Table I-10. National Pattern of R&D: Estimated 1990 Expenditures and 2-Year Constant Dollar Changes, 1988-90 (in millions)

Performers of R&D	Sources of Funds: Federal Government	Industry	Colleges & Universities	Nonprofit Institutions	Total Funds for R&D
Estimated 1990 Expenditures					
Federal Government	$16,700	$0	$0	$0	$16,700
Industry	35,650	72,200	0	0	107,850
Colleges & Universities	9,200	1,150	4,300	1,150	15,800
Federally Funded R&D Centers	5,250	0	0	0	5,250
Nonprofit Institutions	2,400	600	0	1,100	4,100
TOTAL, R&D Performers	$69,200	$73,950	$4,300	$2,250	$149,700
2-Year Percent Change In Constant Dollars (1988–90)					
Federal Government	7.5%	0.0%	0.0%	0.0%	7.5%
Industry	1.7%	0.2%	0.0%	0.0%	0.7%
Colleges & Universities	3.6%	18.5%	15.0%	13.9%	8.2%
Federally Funded R&D Centers	6.5%	0.0%	0.0%	0.0%	6.5%
Nonprofit Institutions	0.3%	10.3%	0.0%	15.6%	5.4%
TOTAL, R&D Performers	3.6%	0.5%	15.0%	14.7%	2.5%

Source: National Science Foundation/SRS, *National Patterns of Science and Technology Resources, 1990*

Amounts represent current operating costs based on data from performers of R&D and therefore do not correspond exactly to the figures for R&D in the budget elsewhere in this report. Capital expenditures for R&D are generally excluded.

Table I-11. National Funds for R&D by Source of Funds (in millions)

	FY 1975 Actual	FY 1980 Actual	FY 1988 Actual	FY 1989 Estimate	FY 1990 Estimate
Current Dollars					
Federal Government	$18,109	$29,453	$61,402	$65,850	$69,200
Industry	15,820	30,913	67,602	70,100	73,950
Colleges and Universities	749	1,318	3,437	3,850	4,300
Nonprofit Institutions	535	909	1,803	1,950	2,250
TOTAL	$35,213	$62,593	$134,244	$141,750	$149,700
Constant FY 1982 Dollars					
Federal Government	$30,986	$34,548	$50,848	$52,247	$52,675
Industry	26,679	36,066	55,748	55,362	56,044
Colleges and Universities	1,302	1,555	2,862	3,073	3,291
Nonprofit Institutions	916	1,066	1,494	1,548	1,714
TOTAL	$59,883	$73,235	$110,952	$112,230	$113,724
TOTAL R&D, Percent of GNP	2.2%	2.3%	2.8%	2.7%	2.7%

Source: National Science Foundation/SRS, *National Patterns of Science and Technology Resources, 1990*, and *Budget of the United States Government, FY 1991.*

Amounts represent current R&D operating costs based on data from performers of R&D and therefore do not correspond to the figures for R&D in the budget elsewhere in this report. Capital expenditures for R&D are generally excluded.

Table I-12. National Funds for R&D by Performers of R&D[1] (in millions)

	FY 1975 Actual	FY 1980 Actual	FY 1988 Actual	FY 1989 Estimate	FY 1990 Estimated
Current Dollars					
Federal Government	$5,354	$7,632	$14,281	$15,800	$16,700
Industry	24,187	44,505	98,435	102,750	107,850
Colleges and Universities	3,409	6,060	13,422	14,450	15,800
FFRDC's[2]	987	2,246	4,531	4,850	5,250
Nonprofit Institutions	1,276	2,150	3,575	3,900	4,100
TOTAL	$35,213	$62,593	$134,244	$141,750	$149,700
Constant FY 1982 Dollars					
Federal Government	$9,308	$9,006	$11,892	$12,611	$12,782
Industry	40,781	51,919	81,163	81,136	81,723
Colleges and Universities	5,927	7,151	11,176	11,534	12,093
FFRDC's	1,716	2,650	3,773	3,871	4,018
Nonprofit Institutions	2,151	2,508	2,948	3,080	3,107
TOTAL	$59,883	$73,234	$110,952	$112,231	$113,724
TOTAL R&D, Percent of GNP	2.2%	2.29%	2.75%	2.71%	2.68%

Source: National Science Foundation/SRS, *National Patterns of Science and Technology Resources, 1990.*

[1] Amounts represent current R&D operating costs based on data from performers of R&D and therefore do not correspond to the figures for R&D in the budget elsewhere in this report. Capital expenditures for R&D are generally excluded.

[2] Federally Funded Research and Development Centers.

Part II: Agency R&D Budgets

Introduction

In this section, R&D in the federal budget is examined through the agencies that support and perform the work. Separate chapters examine the R&D activities of the principal R&D agencies. These are followed by budget tables, starting with a summary table of R&D budget totals by agency from FY 1989 to FY 1991 and followed by detailed budget tables for each major agency, to support discussions of the Bush Administration's programs and policies for R&D.

The discussions of agency R&D programs assess budget trends and policy choices reflected in the FY 1991 budget in as detailed a manner as possible. Some agencies have been treated in greater depth than others, reflecting differences in availability of information or issues of special importance. Aspects of certain important agency R&D budgets which do not appear in this section may be found in the disciplinary analyses in Part III. For instance, although there is no chapter devoted to NOAA in this section, a discussion of its programs is contained in Chapter 14, "FY 1991 R&D in the Atmospheric and Oceanic Sciences."

Budget figures in the detailed agency tables may not correspond exactly to the amounts in the summary tables here and elsewhere in the report. The data in the summary tables were generally prepared based on OMB and NSF data, while the agency tables were derived using agency budget justifications. R&D is often not managed or budgeted by the agencies in categories which correspond exactly to those used by OMB and NSF for statistical purposes. Where significant differences have been found, they are discussed in footnotes to the agency tables.

Where trends in constant dollars are shown, our calculations are based on the fiscal year deflators developed by OMB to reflect differences in rates of inflation in defense and nondefense R&D costs.

Agency Summary

The composition by agency of the totals for conduct of R&D and R&D facilities is shown in Table II-1. The numbers are drawn directly from the budget authority data compiled by OMB for their analysis of the FY 1991 budget.

The last column of the table shows the percentage change in constant dollars from FY 1990-91 -- "real" dollar figures, intended to reflect trends in the purchasing power of agency R&D allocations. These figures highlight several trends discussed in detail in the sections which follow.

Chapter 5

R&D in the FY 1991 Department of Defense Budget

American Association for the Advancement of Science

Albert H. Teich

Highlights

- Reflecting the changing world situation and domestic political climate, President Bush's FY 1991 budget includes $295 billion in budget authority for the Department of Defense. This represents a 1.2 percent increase over the comparable FY 1990 figure. Outlay estimates are above FY 1990, but are $300 million below actual FY 1989 outlays. Virtually all observers expect the actual appropriation for FY 1991 to be substantially below the request.

- Budget authority for R&D in the Department of Defense budget would total some $39.2 billion in FY 1991. This reflects a 3.5 percent increase over the estimated $37.9 billion authorized for R&D in FY 1990. Even this modest growth is unlikely to be approved by Congress.

- Defense development, testing and evaluation, which make up more than 90 percent of DOD R&D, would continue to increase faster than defense research in the proposed FY 1991 budget -- 4.1 percent versus 3.3 percent. The differential is substantially less than in prior years' proposals, however.

- A 25 percent increase (to $4.5 billion) is requested for the Strategic Defense Initiative. Congress cut the FY 1990 SDI budget below its FY 1989 level, however, and is not likely to go along with this proposal.

- Basic research in DOD would gain nearly 6 percent over its FY 1990 level. Despite this increment, defense basic research would be barely more than half its FY 1965 total, in constant dollars.

The Defense Budget and the Changing World Situation

The politics and economics of defense spending have been dramatically affected by the developments of the past several months in Eastern Europe and the Soviet Union. Just as the Berlin Wall stood for 30 years as an icon of the Cold War, its almost spontaneous demolition in December 1989 marked the end of that era in a way that few -- either in the East or the West -- would have dared predict even up to the time it happened.

The overnight disappearance of Communist dictatorships in the nations of Eastern Europe and the unprecedented turmoil in the Soviet Union have made the military scenarios on which U.S. defense policy are based seem hopelessly out-of-date. The new situation, however, is too new and too unstable to allow a consensus to emerge in the NATO alliance, in the United States, or even within the Administration, on how to respond. While the new situation is full of perils, it seems clear that the risk of nuclear confrontation between the U.S. and U.S.S.R., and the possibility of a Soviet move against Western Europe, are increasingly remote. Little is certain about either the short- or long-term impact of all of this, except that it will undoubtedly reduce the priority of military spending in the U.S. and among its allies.

These international developments are coming at a time when the political consensus underlying the rapid defense build-up of the early 1980s has all but unraveled under increasing economic and budgetary pressures. After growing at the rate of nearly ten percent a year (in current dollars) from FY 1980 to FY 1988, outlays for national defense slowed to a growth rate of less than five percent in FY 1989 and are expected to fall more than two percent in FY 1990.

President Bush's budget for FY 1991 reflects these rapidly changing circumstances to the extent one might expect in a document that takes most of a year to prepare. It includes $303 billion in proposed outlays for national defense. While this represents a 2.3 percent increase over estimated FY 1990 spending, it is in fact $300 million below actual FY 1989 outlays. (See Table I-1.) Budget authority for DOD in the FY 1991 request is $295 billion (up 1.2 percent of FY 1990). Despite the relatively modest size of this increase (at least compared to much of the Reagan era), virtually all observers of the budget scene expect the actual appropriation for FY 1991 to be substantially less.

As in recent years, it is likely that the national and congressional debate over defense spending will take place in terms of its overall level, its real growth, and its status in relation to nondefense spending. The centrifugal forces inherent in a declining budget -- constituency-based conflicts over procurement decisions (especially terminations of major weapons systems) and base closings -- will also play a significant role, as they did last year.

R&D and the Defense Budget

Within the overall FY 1991 defense budget, some $39.1 billion is requested for RDT&E in the Defense Department. (We generally use the term "R&D" as synonymous with "RDT&E," but see the discussion at the end of this chapter.) This reflects a 3.5 percent increase over the estimated $37.9 billion being spent on R&D in FY 1990, but it is, in fact, a decline of 0.7 percent in constant dollars. Even in current dollars, it is only marginally above the FY 1989 level of $38.6 billion. (Table I-7 provides more significant digits.)

The huge size of the defense budget and the constraints of national security that apply to it mean that information on defense R&D is not generally available at a level of detail comparable to that in the civilian agencies. In addition, defense nomenclature is loaded with acronyms and code names -- e.g., "LINK BURCH," "SEA LANCE," "Meridian," and "Tacit Rainbow" -- making it virtually inaccessible to most outsiders.

Our analysis in this chapter, therefore, is much more of a broad-brush look at the defense R&D picture than the comparable analyses of civilian agency R&D budgets elsewhere in this book. Our situation is not unlike that in OMB, the Congress and the media, all of which scrutinize defense R&D in considerably less detail than R&D in civilian agencies (although Congress and OMB of course take a much deeper look than we do). This year, in fact, consistent with the Administration's anti-glasnost approach to budget information, the picture on defense R&D is even less articulated than usual. The data available are presented in Tables II-2 through II-6. These tables slice through the proposed $39.2 billion budget by category, military department, and character of work, as well as look in more detail at basic research funding and at long-term trends in defense R&D.

In looking at these tables the reader should be careful not to fall victim to the confusion over the figures for DOD (defense) R&D and those for "national defense." A significant amount of defense-related work is carried out in the Department of Energy (DOE), mainly under its "atomic energy defense activities" (AEDA) appropriation category. These programs include nuclear weapons and naval reactors R&D. The term "national defense" (as used in the overview tables discussed in Chapter 1 of this report) includes these DOE programs. This chapter, since it is devoted to programs in the Department of Defense, does not include the DOE programs, and thus its totals are about $3 billion lower than the "national defense" figures cited elsewhere.

Aspects of Defense R&D in FY 1991

Table II-2 shows the distribution of DOD's R&D budget by major program area. Total R&D in the FY 1991 request, as noted above, is $39.2 billion. Of this amount, $38.1 billion is contained in the RDT&E appropriation, while another $1.1 billion is included in other DOD appropriations -- mainly in military personnel and construction. Most of the total is devoted to conduct of R&D; less than $500 million is allocated to construction or renovation of R&D facilities.

Compared to past years, the differences in percentage changes from the previous year are much less pronounced among major program areas. All program areas in the RDT&E appropriation show an increase; the largest is 8.9 percent in defense-wide mission support, the smallest is 0.3 percent in tactical programs. Advanced technology development, which includes SDI, is slated for a 7.8 percent increase.

Technology base programs (research plus exploratory development) would continue to increase more slowly than overall RDT&E under the proposed budget (3.3 percent versus 3.5 percent), but the differential is less than in prior years. Basic research (category 6.1 in DOD's budgeting system) would increase 5.9 percent to $978 million, after dropping more than $25 million last year. The increase would beat the rate of inflation by a couple of percentage points for the FY 1990-91 period, but would lag inflation substantially over the two-year, FY 1989-91 span.

The budgets for the three military departments and the defense agencies would be treated quite differently under the FY 1991 proposals. The Army and the defense agencies as a whole would increase significantly, while the Navy and Air Force would lose ground. (See Table II-3.) Among the defense agencies, SDI is again a big winner -- at least at this stage of the game -- up nearly 25 percent, and new line items are shown for the Special Operations Command ($207 million) and the Joint Chiefs of Staff ($85 million).

DARPA -- the Defense Advanced Research Projects Agency -- DOD's home for high-risk, high-payoff research, is slated for a 12 percent cut to $1.1 billion. DARPA has many admirers in the legislative branch, and Congress has generally added money back to DARPA's budget in recent years. DARPA funds those DOD programs that are most likely to have impacts on the civilian economy: superconductivity, high definition television and semiconductor manufacturing technology (through the SEMATECH consortium).

Test and evaluation functions, relatively small budget items at the bottom of the chart, are shown receiving large increases. Congress failed to grant similar increases to these units last year.

Table II-4 shows the pattern in defense R&D by character of work. Here the story is a bit different than in recent years. Development (which includes testing and evaluation, as discussed below) is slated to receive a 4.1

percent increase. While this is greater than the 3.3 percent growth in research, it is a far cry from the 11.1 percent increased requested (and denied by Congress) last year. In constant dollars, as shown in the lower half of the table, most of the changes are not very far from the expected rate of inflation.

The breakdown of defense basic research by military service and by components is shown in Table II-5. In-house independent research, through which DOD supports basic research in its own laboratories, would grow significantly in each of the services, as well as in the defense agencies. The University Research Initiative would again be funded at slightly less than $100 million, its level for the past two years, despite an original appropriation of $141 million in FY 1989.

Finally, some of the most interesting information about defense R&D can be gained from Table II-6, which shows trends in both total DOD R&D and basic research from FY 1965 to the present in both current and constant dollars. Since FY 1965, total defense R&D has grown from $6.9 billion to a proposed level of $39.2 billion. The effects of inflation, however, mean that the purchasing power of $39.2 billion in FY 1991 is just slightly more than that of $6.9 billion in FY 1965.

In basic research the long-term trends are even more striking. Although current dollar totals have grown from $347 million to $978 million over the period, the purchasing power of defense basic research funds are now little more than half of what they were in FY 1965.

R&D Versus RDT&E: A Postscript

As noted earlier in this chapter, the DOD programs discussed here are categorized as RDT&E (Research, Development, Testing and Evaluation) rather than just R&D as in the discussions of other federal agencies in this book. The inclusion of testing and evaluation, activities related to but distinct from research and development, in defense R&D statistics has been more or less taken for granted for the past 30 years. Our analyses, like those of OMB and NSF's Division of Science Resources Studies, tend to treat the R&D and RDT&E as essentially synonymous, lumping testing and evaluation in with development for comparisons with other agencies. Recently, however, questions have been raised about the appropriateness of this practice and its possible impacts on science policy.

Testing and evaluation make up by far the largest share of defense RDT&E, dwarfing the technology base programs that are most directly comparable to research in the civilian sector. T&E has also been the fastest-growing component of defense RDT&E during the past decade. As the numbers have grown, some observers have become concerned about them, and have suggested that defense testing and evaluation are so different from both defense and civilian R&D, and contribute to the national scientific and technological enterprise in so different a manner, that it is misleading to include them in R&D statistics. Doing so may be creating an inflated impression of the size of the national R&D effort and its relation to our gross national product.

The matter is of more than academic interest, for debates on national science and technology policy, comparisons to other nations, and expectations of economic performance all depend to some extent on the validity of R&D statistics. A committee of the National Academy of Sciences is studying the matter at the request of the Senate Budget Committee, and a report is expected in the near future. At the least, the report should serve to stimulate broader discussion of this topic.

Chapter 6

National Science Foundation, FY 1991

Association of American Universities

John C. Crowley, Patricia Ann Levy

Illusion and Reality On the Doubling Path: Three Years of Research Losses, And Now, A New Goal

In 1987, the Administration announced a commitment to double the budget of NSF to $3.2 billion in five years, by Fiscal Year 1992. For three years budgets proposed increases in line with that goal, but Congressional appropriations effectively abandoned it. Now, for Fiscal Year 1991, a new, more restrained goal is announced: $3.2 billion will be achieved in Fiscal Year 1994, two years later.

After three years on the doubling path, a contradictory reality glares from the FY 1991 budget: most research programs are not gaining ground consistent with announced national goals and documented needs. Instead, they are weakening steadily. Despite good intentions on all sides, the game plan is losing.

At the pace of the last three years, the Foundation's total budget will indeed double over time, but the goal will not be achieved for most core research programs until after the year 2020. By then, unless corrective steps are taken, the Foundation's core research activities will have shriveled, in real terms, by perhaps two-thirds.

Between Fiscal Years 1988 and 1990, 56 of 84, or two-thirds, of the competitive research programs in four major research activities (Mathematics and Physical Sciences; Engineering; Biological, Behavioral and Social Sciences; and Computer and Information Sciences) have been cut, in real terms, to below their 1988 levels.[1]

As a result of these trends, many researchers in these fields essential to our technological and economic development feel little renewed vigor seemingly promised in 1987. Instead they see and experience the effects of an eroding competitive position. Meanwhile, as young researchers and graduate students ponder their career prospects, many consider more attractive alternatives.

Last year, after reductions imposed by appropriations committees, the first partial sequestration under the Gramm-Rudman-Hollings (G-R-H) budget law and a levy imposed on all agencies to pay for the war on drugs, the 14 percent increase for ongoing Research and Related Activities was cut in half, and many programs continued to absorb real reductions.

As a result of these reductions, all 1990 increments to existing awards were reduced by 2 percent in order to free funds for new investigators and projects. Nevertheless, 4,700 fewer researchers and graduate students will be supported than planned for. No new interdisciplinary science and technology centers will be awarded. The entire class of new awards is being deferred to FY 1991 in order to avoid what Director Bloch's report to Congress described as "unacceptable and unintended disruption" of other programs.[2]

In welcome contrast to the research budget, investment in the NSF's Science and Engineering Education programs continued to grow at a pace exceeding that required by the doubling goal. Last year, as Congress cut research programs, it again added funds to the budget request for education programs, yielding a 19 percent increase for them. In four years, the Science and Engineering Education Directorate has grown from $99 million to about $207 million, and human resources components of the research programs continue to grow in real terms. The problem is commitments to research programs simply have not kept pace.

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[1] In addition, as program managers increase the number of awards in response to proposal pressure, the real value of awards is declining.

[2] Recent commitments to new S & Tand Engineering centers, some argue, account for the erosion of the core research programs; they should be terminated and the funds reallocated to core programs. Such a shift of about five percent of research funds into core programs will not close the gap, but it will be disruptive, divisive and wasteful. Centers have begun to produce excellent research andto foster new collaborations. If any centers are merely marketing schemes to persuade reluctant policy makers that something, new and exciting is happening, they deserve to be questioned. Those that demonstrate research merit deserve support consistent with their awards. But, centers probably will be attacked anyway. In tight times, some in the community seem inclined to circle the wagons and fire into its circle.

In light of this recent history, why do key congressional staff and some in the research community believe that the NSF budget could fare better in Congress this year? It is because, for the first time in perhaps ten years, the budget requests for the other agencies funded by the VA, HUD, and Independent Agencies appropriations bill are good to very good. This year, House and Senate Appropriations Subcommittees could be spared the politically difficult task of funding veterans medical care, public housing, environment, space and NSF programs at each other's expense, if, and this is a large assumption, the Budget Resolution permits an allocation of funds among the 13 appropriations subcommittees equal to the budget requests of the agencies in the VA, HUD, and Independent Agencies bill. Then, subcommittees could fund NSF, and their other agencies, at, or near, the budget request.

This is both good news and bad news for NSF. Budget gimmicks and political gamesmanship again permeate the budget, and Congress will be pressured to shift funds from NSF and other favored agencies to inadequately funded programs, including education and health research. Many are looking at the VA, HUD, IA bill with knives sharpened.

Recent research by Edwin Mansfield shows the annual rate of return on investment in basic research to be about 28 percent. The question then becomes whether, if necessary, the nation ought to borrow funds from foreign competitors at 8 or 10 percent interest.

If recent policy choices hold, the new doubling "scenario" also will fail. The adverse consequences of such failure for the nation's leadership in research and education in science and technology are predictable. As history accelerates around us, as Czechoslovakian President Vaclav Havel has described our time, the United States is not only failing to meet its stated goals for NSF; it also is risking international leadership in science and technology by failing to keep pace with the foreign competition.

It is impossible to predict this year's outcome. Macro international, political and budget issues, as well as personalities, again will dominate the process, one an experienced congressional staffer accurately describes as "a game within a game within a game." But this year, there is a fresh, albeit constrained, opportunity, before the game's unpredictable end, to bring NSF's budget into alignment with national goals and needs. More widespread understanding of the true financial condition of the NSF's core research programs would help improve the quality of debate.

Highlights of the Fiscal Year 1991 Budget

Summary

Total Request	$2.38 billion	+ $300 million, 14.4 percent
R&RA	$1.95 billion	+ $229 million, 13.3 percent
S&E Education	$.251 billion	+ $46.7 million, 22.8 percent
Antarctic Program	$.175 billion	+ $23.2 million, 15.2 percent
Inspector General	$3.00 million	+ $440 thousand, 17.2 percent,

Themes

- strengthen the research base, research equipment and facilities ($1.81 billion, + 11 percent).
- develop human resources, broaden participation, at all points in the educational pipeline from kindergarten to postdoctoral training ($463 million, + 30 percent)

Science and Technology Centers (STCs) $25 million

The research programs are now responsible for the first class of STCs. Many of these are not fully funded, but will be if the 1991 budget is fully appropriated. A second class of 10 to 12 centers, deferred from Fiscal Year 1990, is planned. Awards from proposals submitted in late 1989; are anticipated in the fall.

Biological, Behavior and Social Sciences	$ 6.325 million
Computer and Information Science and Engineering	2.750 million
Geosciences	3.425 million
Mathematical and Physical Sciences	12.500 million

NSF Estimates of Proposals, Awards and People Supported

- 52,000 proposals, $11.7 billion requested,18,908 awards
- universities and colleges, $1.7 billion; industry,$117 million
- 22,514 scientist; 4,153 postdoc; 18,987 grad students

Education and Human Resources

K-12	$165 million	+17.8 percent

Efforts continue to improve teaching, materials and informal science education, and to forge federal-state partnerships.

Undergraduate	$134 million	+48.4 percent

Research programs have $84.23 million, or 63 percent, of undergraduate funds; the SEE Directorate, $50 million. Curriculum redesign in science, mathematics and engineering and Engineering Education Coalitions for curriculum reform get $35.5 million, up from $16 million. Instrumentation and laboratory equipment receive $26 million, an increase of more than 18 percent. Research Experiences for Undergraduates are slated for $14 million. The number of Career Access centers increases to 16.

Graduate/Postdoc/Professional	$164 million	+ 29.1 percent

Graduate fellowships increase by 100 to 1100, double the 1987 level. A new Global Change Research Education and Training Program (40 postdocs, 80 graduate and 200 undergraduate students) is established. New Research Training Group awards will enhance multidisciplinary Ph.D. training. Postdoc programs in mathematics, chemistry, environmental biology and plant sciences expand. 200 new awards in the Presidential Young Investigators program, for a total of 950, and a $94 million, or 48.5 percent increase for minorities, women and disabled are planned. A Faculty Recognition Awards for Women program is established.

Underrepresented Groups $31 million + 49 percent

An NSF-wide effort seeks to improve participation by students, faculty, institutions, especially women, minorities and the disabled.

NSF Headquarters Relocation $5.50 million

An announcement in April; a move in mid-1992.

Biological, Behavioral, and Social Sciences

$327.5 million + 11.6 percent

- 30 percent supports new P.Is in new lines of research.
- 22 percent supports personnel, instrumentation, facilities and datasets.
- NSF provides over 50 percent of total federal support in plant biology; 75 percent in environmental biology; 95 percent in anthropology; 95 percentin systematic biology; nearly one-third in the behavioral and social sciences, including two-thirds in economics.
- Increases: Behavioral and Neural Science, 7 percent; Molecular Biosciences, 8.2 percent; Cellular Biosciences, Biotic Systems and Resources, and Social and Economic Sciences, 10 percent.
- Cross-disciplinary: plant sciences ($4.47 million) for the genome project, Global Environmental Changes ($5.25 million), and Computational Biology and Databases ($1.53 million).
- Support for instrumentation and graduate students is up.
- Additional science and technology centers, $6.42 million.

Changes in BBS Programs for the Period Fiscal Year 1988 - Fiscal Year 1990, in Current and Constant Dollars

Changes in funding for the 23 programs of the five major divisions of the BBS Directorate, excluding Instrumentation and Resources and Science and Technology Centers are:

- In current dollars, seven programs increased a total of five percent or less. Eight programs increased between five and ten percent and eight others, including four of five in Biotic Systems and Resources, increased by more than ten percent.

- In constant Fiscal Year 1988 dollars, fourteen of the twenty-three BBS programs dropped below Fiscal Year 1988 levels. Six programs grew up to five percent. Three programs grew more than eleven percent.

- Instrumentation and Instrument Development was cut 8.2 percent in real terms.

- S&T Centers go from $4.9 million to $11.3 million,up 131 percent, to fully fund two 1989 centers and award another.

Computer and Information Science and Engineering

$193.25 million + 13.8 percent

- NSF provides over 40 percent of federal funds for research computer science.
- Double digit increases are proposed for Computer and Computation Research, up 10.5 percent; Information, Robotics and Intelligent Systems, up 14.5 percent, and Microelectronic Information Processing Systems, up 13.6 percent.
- NSFNET is the core national research and educational network; more than 150,000 computers at over 350 academic and industrial institutions in all 50 states have access to NSFNET. A $9.1 million, or 41 percent, increase is proposed for Networking and Communications Research and Infrastructure.
- Research in software development, high performance computing and collaboration technology are emphasized.
- New multi-disciplinary projects are proposed in Scientific Data bases ($1.75 million) and Application-Specific Comput-

ing Systems ($2.96 million).

- An increase of $2.75 million, 41.9 percent, to fully fund two 1989 S&T centers and to establish new ones
- Defunding one Advanced Scientific Computing center in 1989 will permit full funding of the remaining four centers.

Changes in CISE Program Elements for the Period Fiscal Year 1988-Fiscal Year 1990, in Current and Constant Dollars

Changes in the 14 programs of the Computer and Computation Theory; Information, Robotics and Intelligent Systems; and Microelectronic Information Processing Systems divisions are:

- In current dollars, one program declined, by one percent; four programs grew by 3 to 7 percent. Four programs grew between ten and twenty percent. Increases greater than twenty percent went to Numeric and Symbolic Computation; Software Engineering; Information Technology and Organizations; Experimental Systems; and Systems Prototyping and Fabrication.

- In constant Fiscal Year 1988 dollars, five programs (Computer and Computation Theory, Computer System Architecture; Software Systems; Knowledge and Database Systems and Interactive Systems) declined in real terms by between 1.4 percent and 8.6 percent. Microelectronic Systems Architecture; Design Tools and Test and Circuits and Signal Processing grew by between two and three percent. Robotics and Machine Intelligence went up 5.3 percent; Software Engineering, 17.1 percent; Numeric and Symbolic Computation, 26 percent; Information Technology and Organizations, 27 percent; Experimental Systems, 38.6 percent and Systems Prototyping and Fabrication, increased by 35.1 percent.

- Advanced Scientific Computing has increased by 29.2 percent; Networking and Communications by 77.9 percent and Cross Disciplinary Activities by 7.0 percent, in real terms.

Engineering

$226 million +12.9 million

- NSF provides 27 percent of Federal support for engineering research; DOD, 44; NASA, 12, and DOE, 9 percent.
- In fiscal year 1990, from a 6.9 percent overall increase, three new Engineering Research Centers were awarded.
- A 19.1 percent, or $8.9 million, increase to $55.3 million is proposed for Engineering Centers to fully fund all 19 centers; no new centers are planned. The states, 400 firms and universities more than double NSF's contributions.
- A 35.8 percent increase to $5.2 million is proposed for 48 Industry/University Cooperative Research Centers. On average, each NSF dollar draws ten others from firms and states. Four new Centers are planned for Fiscal Year 1991.
- Research support increases by $5.7 million, or 5.9 percent.
- A new Engineering Infrastructure Development Subactivity, established in 1990, manages education, equipment and instrumentation and human resources programs. An increase of $8.6 million, or 51.2 percent, is proposed to start two new education coalitions ($5 million), for a total of five; expand Research Experiences for Undergraduates; pilot undergraduate courses; establish a Faculty Awards for Women program and strengthen programs for minorities.
- 22 more Presidential Young Investigators, or a total of 375.

Changes in Engineering Program Elements for the Period Fiscal Year 1988 - Fiscal Year 1990, in Current and Constant Dollars

Changes in the 20 programs of Biological and Critical Systems, Chemical and Thermal Systems, Electrical and Communications Systems, Mechanical and Structural Systems, and Design and Manufacturing Systems are:

- In current dollars, twelve of twenty programs have declined, most by three to seven percent.
- In constant 1988 dollars, eleven have been cut by more than ten percent; five by two to nine percent.

- Engineering Research Centers increased by 28 percent, or 18 percent in real terms. Industry/University Cooperative Research Centers increased more than 13 percent in real terms.

Geosciences

$383.7 million +18.1 percent

- Provides more than 50 percent of support in atmospheric and earth sciences; 70 percent in ocean and arctic research
- Increases: 15.4, 19, and 16 percent for Atmospheric, Earth and Ocean sciences programs respectively.
- $11.5 million more for new awards and instrumentation.
- $3.5 million for a second S&T center; fully fund the first.
- Global Change gets more than 20 percent of the funds; Global Geoscience, $33.8 million, and instrumentation in Earth Sciences, $4 million.
- Education receives an $11 million increase.

Changes in Geosciences Program Elements for the Period Fiscal Year 1988 - Fiscal Year 1990, in Current and Constant Dollars

- In current dollars, all research programs increased from 14 to more than 30 percent.
- In constant 1988 dollars, most programs increased between 1 and 9 percent.

Mathematical and Physical Sciences

$621.5 million + 11.6 percent

- MPS accounts for 32 percent of the total R&RA budget.
- Overall, NSF provides 44 percent of total federal support for academic research in MPS disciplines; more than half in mathematics, two-thirds in ground-based astronomy, one-third in elementary particle physics, half in nuclear physics, 40 percent in chemistry and half in materials. FY 1990 budget cuts left MPS funding essentially flat.

- A special appropriation will replace the fallen Green Bank Telescope (GBT) in 1995. Major Research Equipment, is GBT plus the National High Magnetic Field Laboratory.
- Four of five disciplinary research programs are adjusted for inflation; only astronomy receives significant real growth. Increases are: Materials Sciences, 6.7 percent; Astronomical Sciences, 9.9 percent; Physics, 5.2 percent; Chemistry 5.5 percent and Materials Research 5.6 percent.
- Across all MPS disciplines, funding for new investigators is increased by $4.8 million; 60 new research awards in emerging areas for young researchers are planned. Of these, 20 are in mathematics and 20 are in chemistry. New Presidential Young Investigator awards also are planned.
- S&T Centers receive $27 million, an increase of 86 percent or $14.5 million. 1990 cuts forced 2 percent reductions in second-year funding for six of eleven 1989 centers: four in materials research, one in chemistry and one in astrophysics.
- $575 million is for research and facilities, an increase of $52 million. $20 million is requested for the Laser Interferometer Gravitational Wave Observatory and two 8-meter Optical/Infrared Telescopes. Also, $5 million is requested for upgrade of the Arecibo Observatory. Other instrumentation receives $94 million, up $10 million.
- Superconductivity research continues at $24.1 million.
- Construction of the delayed, Very Long Baseline Array radio telescope continues; completion is planned for FY 1993.
- Education and human resources receive $46 million, up $12 million, or 35 percent, especially for women and minorities.
- Graduate research assistants increase by 7 percent.
- Undergraduate activities increase by a third to $18 million.

Changes in MPS Program Elements for the Period Fiscal Year 1988 - Fiscal Year 1990, in Current and Constant Dollars

- In current dollars, four programs declined: elementary particle physics, chemical instrumentation, chemistry special projects and material research project support.
- In constant dollars, 21 of 27 program elements declined to below 1988 levels. Elementary particle physics, chemical instrumentation and chemistry special projects declined by

12.2 percent, 11.3 percent and 25.4 percent respectively. Materials project support declined by 8.5 percent, materials laboratories by 5.3 percent. Others lost two to five percent.

Research Facilities Modernization

$20 million — No Change

The request equals the initial appropriation. The first awards will be made from FY 1990 and 1991 funds in the fall of 1990.

Scientific, Technological, and International Affairs

$74 million — + 16.6 percent

- Increases are concentrated in Research Initiation and Improvement, up 23.5 percent to $32.2 million, and Industrial Science and Technological Innovation, up 14.4 percent to $22.9 million.
- 55 percent of total STIA funds support research across all research areas.
- 450 awards in international activities are planned, with emphasis on U.S.S.R. and Eastern Europe.
- Minority Centers of Excellence: the 1990 level, $5.8 million.
- Education and Human Resources programs account for 44 percent, or $33.2 million, of STIA funding. Individual and Group Support for Women and Minorities get a 103 percent increase, to $11.5 million.
- The Experimental Program to Stimulate Competitive Research (EPSCOR) is fully funded at $9.8 million to continue work in 16 states and Puerto Rico.
- Small Business Innovation Research Program: from 1,625 proposals 240 awards, totaling $22.5 million, are planned. SBIR, established first in NSF in 1977 and later extended to eleven other agencies, is funded by law at a level equal to 1.25 percent of total NSF extramural research.
- A new $.4 million College and University Innovation Research program is planned in response to a congressional mandate to facilitate development of new high-technology

products derived from academic research results; 16 awards, matched from NSF research programs, are planned.

U.S. Antarctic Program

$175 million + 15.4 percent

- Safety, Environment and Health Initiative: $17 million
- Research is up $1.98 million, or 11.7 percent, to $19 million.

Science and Engineering Education

$251 million + 22.9 percent

- Congress increased FY 1990 funding by $14.3 million above the request, providing nearly a 20 percent increase over Fiscal Year 1989. After G-R-H budget cuts, precollege programs increased by 17.8 percent to $140 million, undergraduate programs increased by 21.4 percent to $34 million, and graduate programs increased by 24.7 percent to $29.9 million.
- Precollege increases by 17.6 percent to $165 million, undergraduate by 47.1 percent to $50 million and graduate programs increase by 20.1 percent to $35.9 million.
- By program: Teacher Preparation and Enhancement, $89.6 million, up 10.6 percent; Materials Development, Research, and Informal Science Education, $61.5 million, up 28.1 percent; Undergraduate Science, Engineering, and Mathematics Education, $50 million, up 47.1 percent; Research Career Development, $4.9 million, up 21.7 percent; and Studies and Program Assessment, $5 million, up 14.4 percent.
- 1100 new graduate fellowships are planned, completing the doubling from 560 awards in Fiscal Year 1987. The stipend will increase to $13,500 per year; no change in the $6,000 cost-of-education allowance is proposed. Minority Graduate Fellowships increase to $5.4 million. The Young Scholars Program increases by 28.6 percent to $9 million; 6.500 students will participate.

Chapter 7

Health Research (HHS) in the FY 1991 Budget

National Association of State Universities and Land-Grant Colleges

Jerold Roschwalb

Introduction

Suspicion born of experience proved an obstacle this year. The Administration's proposed budgets for FY 1991 for NIH and ADAMHA are almost wholly devoid of any euphemistic complexities. There are no suggestions for modifying A-21-indirect costs, or providing a new forward funding mechanism. What you see is what is intended.

What you see could be termed a reasonable budget for NIH and a somewhat enhanced budget for ADAMHA. Some critics suggest that OMB undermined its goals in past years by proposing sharp cuts for NIH, only to find its proposals rejected out of hand by the Congress, which, in turn, voted very substantial increases for the agency. In the past two years, the OMB changed its style, proposing increases of six or seven percent and found the Congress adding very little to them in the final appropriations.

Any theory so neat about the congressional appropriation process overlooks other factors such as the immediate fiscal situation controlling congressional decisions. Nevertheless, this year's NIH budget follows the past two years with a 4.7 percent increase overall (reduced to 3.7 percent if AIDS and human genome funding are excluded).

The budget of ADAMHA is more complex, involving grants to states and treatment programs. Its total budget goes from $2.625 billion to $2.832 billion. Research projects grow from $452 million to $494 million, about a 9 percent increase, continuing a recent pattern for the agency -- research grants grew from $370 million to $452 million between FY 1989 and 1990. It is worth noting that when percentages are used to discuss appropriations, it is meet that we give consideration to the base involved. A smaller percentage for a mature program might enable it to keep up the pace; for a program still playing catch-up, a higher percentage could mean relatively few dollars needed to enable it to fulfill its mission.

National Institutes of Health

The definitive story of NIH in the 1980s could be called "The Out Years." This issue lies at the core of debate regarding funding within the research community and within the government, both OMB and Congress. It is rooted in the way multi-year grants work and the duration of their fiscal impact. Two years ago, more than 6,000 competing awards were made by NIH. In 1990 the number is 4,633. But the total number of awards being funded in the two years, over 20,000, is very close, the reason being that awards made a few years ago for periods ranging from three to seven years are still in the system and annually create a commitment base for the agency. They must be funded as implicitly promised and consume a larger percentage of funds appropriated for research project grants (RPG's).

In 1981, the average length of award was 3.3 years. In 1989 that had increased to 4.2. In 1981, the percent of all awards made for five years or more was 19.2 percent. In 1989, it was 50.7 percent. Ironically, this is a sign of success, as the Javits awards and so-called "First Awards" and Outstanding Investigator Grants all joined to contribute to the success in cutting down paperwork in repeated applications by the nation's outstanding scientists. But the pace was not sustained. To keep the level of competing awards at 6,000 or more would have required far more funds that Congress was able to consider under the pressure of annual budget deficits.

1990 had some special elements that affected these numbers as well. Congress authorized a partial Gramm-Rudman-Hollings sequestration of about 1.4 percent costing NIH $96.6 million. The agency also was required to cut programs to help create a $15 million fund for extramural construction projects. NIH also lost $10 million as a salary cap in extramural grants was established. The cap went into place and PIs received $10 million less, but the dollars disappeared from NIH and even from HHS. There were two other reductions involving procurement reform and agency salaries and expenses that added to the cutback. Altogether the agency lost about $120 million from its 1990 appropriation amounting to about 1.5 percent.

Examples of specific impacts of the reductions include a loss of about 120 competing research project grants, an award rate that dropped from 24.8 percent to 24.2 percent, and an increase of about 1.5 percent in average downward negotiations. There were also comparable impacts in research centers (1.2 percent), research training (1.3 percent), and intramural research (2 percent).

Proposed figures for FY 1991 are compared to the post-reduction numbers of 1990 not the appropriated figures. They are absolutely legitimate but reflect better on themselves than they should.

BRSG

Placed under "Other Research," BRSG is comprised of three programs: shared instruments, minority students and the formula program. The latter involves distribution of funds according to a formula that determines how nearly every recipient of NIH research funds will fair in the award of biomedical research support dollars. It includes all the health science institutions, such as medical, dental, veterinary, podiatry, etc. It has been the arena for a long-term squabble essentially between those who would concentrate limited dollars on institutions doing the most and best research and those who would distribute it broadly, if only to maintain its political attractiveness. The Administration has taken the position for more than a decade that the program ought to be eliminated. It is viewed as random, unjustifiable support with no measurable output. Much of the funds are used to bridge support between grants for scientists or as pilot projects, very often for young researchers. However, it is the flexibility of the funds that makes them so very attractive to institutions even if the amounts are limited.

Congress has tended to ignore the Administration's request for eliminating the program and as recently as FY

1989 funded the programs at $88 million. In 1990 the figure was $78.8 million. The $52.97 request is a major change in FY 1991. The formula program is funded at $17.7 million, but one-third of those funds ($5.9 million) is earmarked to assist minority students, part of the agency's thrust in the direction of minority students and institutions. Since there is no simple way to distribute the funds within the formula of BRSG, the $5.9 million will be turned over to the minority high school student program designed to attract young people into the fields of biology and medical research. If the Congress funds the program at the request level, there will be approximately $16 million less each for the pilot research projects and for the regular research support activity in the program.

(At the same time, it is noteworthy that there will be a very substantial increase for Research Centers at Minority Institutions as well as increases for other programs aimed at minority and disadvantaged students. All told, the funding for these programs would rise from $71.4 million in 1990 to $89.6 million in FY 1991.) In the BRSG program, awards would begin with a minimum of $5,000 and a maximum of $30,000.

FY 1991 Budget Policy

Basic research is favored in the total of $7.930 billion, an increase of $353.3 million. This total budget includes $800.2 million for AIDS and an increase of $56.6 million. The Human Genome project receives very substantial funding for the first time, at $108 million, not quite doubling its 1990 appropriation an increase of $48.5 million. Of particular interest is the priority awarded to intramural facilities. For some time there has been concern that buildings and laboratories, including the Clinical Center itself, on the NIH campus were being neglected because of fiscal pressures. This year's budget contains $88.6 million for renovations, modernization, upgradings and repairs. Last year's budget contained $61 million, but, of that, $33 million was committed to the Child Health and Neurosciences facility. This year's budget is entirely oriented toward rehabilitation of campus facilities.

The training program was significantly enhanced last year when individual awards rose from 1,696 in FY 1989 to

1,944 and institutional awards rose from 9,529 in FY 1989 to 9,851. In the early 70's NIH committed 13 percent to training; today -- about 5 percent. There are increases this year to 1,988 for individual awards and 10,032 for institutional awards but they are more moderate.

Intramural research also has been paid additional attention in the past two years, again a response to allegations of neglect. The FY 1989 level was $788.8 million and that rose to $855.9 million in 1990. The request for FY 1991 is $914.9 million.

Percentages and Downward Negotiation

With regard to percentages, the 24 percent award rate on average across NIH anticipated this year tells us some things, but not enough. The rate is compared with early years when, in fact, the award rate had reached a 40 percent level. The community has no doubt that increasing the number of awards substantially would still mean NIH funding science of highest excellence, but the use of precise numbers may be tricky.

For example, a decade ago, the approval rate of applications was about 70 percent compared to the 95 percent today. The current number of awards made on that base would have meant better than a 33 percent award rate. But it is also possible that the quality of applications has increased as the 30 percent rejected earlier dropped out of the competition and the young scholars who took their place were better trained and did better science. That is one conjecture. The key seems to lie in determining how much first rate potential is being unfulfilled in biomedical research rather than fixing an arbitrary award rate.

For many years there has been a minor adjustment of one or two percent to the level of funding recommended for a proposal by the study sections. In recent years, that rate of cuts has increased up to approximately 12 percent last year on average. (That clearly means that while some grants might lose only 5 percent, other might lose as much as 20 percent or more.) Scientists having a substantial portion of their funds cut must either change the scope of their research, if possible, or seek additional support from within their institutions. For this reason, downward negotiations has become a major target of concern.

In response, however, NIH officials point out that the average size of a grant has gone up very substantially. In 1981 the average cost per grant was $107,200. In 1990, the average is $206,600 ($199,600 if AIDS projects are excluded). The argument says that even if you add 40 percent inflation over the past decade, the grant is so much larger that the downward negotiation cuts are not unfair.

Noted also is that the reason why the cost of grants has doubled in the past decade is related to the way science is conducted. Instruments used are much more sophisticated and expensive and require costly maintenance. Computer time now is a norm for much of biomedical research and that is another expense. And, in such areas as biotechnology, the lab assistants must be much better trained and educated and are paid substantially more to back up the work of the scientists.

Clinical Trials

Clinical trials are a paradox in federal funding. Congress understandably finds it difficult at times to give a blank check to basic research, which may lead to significant results but in no time certain, or may only produce negative facts for scientists. On the other hand, research that is "applied" is more appreciated. Clinical trials might be called the most applied of biomedical research, as vaccines are taken to the field or new medications tested or other technologies given an opportunity to be proven.

From within its institute budgets, NIH dedicates about $500 million annually for such trials. Still, NIH records show that for 1990 there was a shortfall of $184.5 million needed to begin new trials. The estimate is that the same situation prevails for FY 1991. One explanation for the shortfall in funding may lie, as noted earlier in research grants, in the phenomenon of "out years." The Cancer Institute needed $49 million to begin 19 new clinical trials in 1990. However, the total projected cost was $213 million over a period of three to five years. Heart, Lung and Blood was even more striking, needing $14.6 million to begin 10 trials but because, for that institute, the length of the trial often ranges to nine or ten years, the total cost of the trials would have been $224.3 million.

The ratios differed among the institutes, but it is clear that the initial cost of under $200 million would have approached $1 billion over the time of the trials. An argument given in favor of this expenditure, notwithstanding its size, is that these are "best bet" investments of therapies ready for the bedside.

AIDS

AIDS continues to be favored in the budget, given its continued impact on American society. The FY 1989 level was $602.3 million, 1990, $743.5 million, and the proposal for FY 1991 is $800.2 million, a 7.6 percent increase. The budget continues its approach of last year, not treating AIDS as a separate phenomenon but integrating it into the entire biomedical research activity of NIH and ADAMHA.

Intramural

Some federal officials argue that since there are obviously ample scientists interested in doing research, the wise tactic would include first increasing intramural research since it is cheaper. Salaries are set by the government and can be controlled. Second, intramural need not be in Bethesda, Maryland, as attractive as that may be for lots of people. The federal government has laboratories all over the country in perfectly acceptable locales, including those near universities.

The other tactic is to repress salaries in the extramural program. "Salaries govern everything." If you notify people in advance what you will accept in the way of applications and costs, you find that if they are interested, they modify their applications accordingly. They take note of the proposed new program at NIH to establish the equivalent of academic chairs and attract extraordinary figures in biomedical research up to $250,000 a year, but they note that this is strictly for a maximum period of five years during which time they do research and not administer and provide leadership for younger scientists.

Alcohol, Drug Abuse and Mental Health Administration (ADAMHA)

The increase over FY 1990 proposed by the

Administration for FY 1991 ($851.4 million/$932.3 million) is 9.5 percent or double that of NIH. Since NIH -- has two institutes, each of which has a larger budget than the entire ADAMHA, and is more than eight times the size of its sister agency, numbers generally do not prove useful for comparisons. It is relatively recent that society has begun to accept alcoholism and drug addiction and even mental health problems as illness instead of character weakness or even supernatural visitations. As a result, decades of research that have gone into the traditional NIH targets of concern still lie ahead of the research scientists supported intramurally and extramurally by ADAMHA. Still, it is impressive that the agency has had its funds increased meaningfully in the past few years. The agency had a major increase for grants over FY 1989 ($369.9 million/$451.9 million). Such an event creates a commitment base so that a current services budget for FY 1991 would be $568.9 million an increase of almost 16 percent. Including all of the mechanisms this makes the 9 percent increase proposed by the Administration at once a favorable figure and only about half of what is needed to carry on the task.

One other way to assess the relative reasonableness of budget requests is to include in the list the so-called professional judgement budget. That budget refers to the levels of funding the senior professionals in the institutes determine as adequate to meet the responsibilities of their programs and cumulatively the agency as a whole. In the case of ADAMHA, the following four numbers bear comparison. FY 1990 ADAMHA had a total for research funding of $851.4 million. The current services budget for FY 1991 would come to $994.4 million for research, an increase of 16.8 percent. The Administration's request for the agency is $932.3 million an increase of 9.5 percent. The professional budget comes to $1.197 billion or an increase of 40.6 percent over FY 1990 and $265 million over the Administration's request.

Again, the thesis applies. This is a high percentage increase but a less impressive dollar figure. Staying with the thesis, it deserves to be noted, that while the professional judgement budget is 40.6 percent over FY 1990, in the outyears, in FY 1995, sustaining that budget would result in a $1.687 billion budget, one that was almost double the FY 1990 budget. Should the nation determine that ADAMHA objectives are of highest import the billion dollars in question would prove to be inconsequential. In the context of FY 1991 calculations by budget and appropriation committees it may be beyond creative contemplation.

Within ADAMHA's research budget all six mechanisms grow: Research Training at $34 million has a 10 percent increase; Intramural Research at $126 million has a 7 percent increase; Research Centers at $91 million has a 5 percent increase; Research Management and Support is at $88 percent has a 12 percent increase; Other Research grows to $108 million, a 17 percent increase and RPG's at $494 million grows approximately 9 percent.

Central Themes

A driving force behind the agency's increases is the national campaign against the use of illegal drugs. Drug abuse spending in the agency was $716 million in FY 1989. Two years later the requested funding is $1.376 billion, approaching a doubling in just those two years. (The increase from 1989 to 1990 was even greater.)

Research is increased by 18 percent for drug abuse research for a total of $300 million. Funds are split between two major categories. One, fundamental research on the impact of drugs in basic biological functions; the second, the development of therapies for treating persons addicted to drugs. In the other institutes, areas of emphasis will include studies of genetic susceptibility to alcohol and drugs as well as a long-term study of molecular genetics of mental illness. Included in the research plans is the establishment by NIMH of a Center for Excellence in Molecular Neurobiology.

A review of ADAMHA RPG's shows a steady and unbroken increase from 1982's total of 1,060 to 1991's proposed 2,403. The one "blip" reflects similar circumstances discussed with NIH. New/competing grants increased in all of those years, but drop in FY 1991 as continuation grants command a larger portion of available dollars. While the number of grants rose by almost 300 between 1988 and 1990 the increase over 1990 will be only 61.

ADAMHA Budget Details

NIMH

Examination of the detailed charts of the Agency show no extraordinary abberations. In the RFG area, as throughout NIMH, the major leap forward in FY 1990 overshadows the good increases proposed for FY 1991 and also shows the impact of the "outyear" phenomenon, new and competing grants went from 309 grants costing $71.6 million in 1989 and 404 grants costing $76.3 million in 1990. In 1991 this number plummets to 278 grants and $54.5 million dedicated to their costs. However, the totals for the three years show 1,045 grants, 1,049 grants, and 1,045 grants at a cost in the three years of $191.5 million, $221.7 million, and $235.9 million.

However, continuation grants explain much. In 1989, the number and cost were 655 and $119.4 million; in 1990, 745 costing $144.2 million. But proposed for FY 1991 are 867 grants (carried over from 1990, 1989, 1988, and even before) costing $180.1 million. This is why a current services budget would require almost twice what the Administration proposes. It also tells why a budget that would maintain this trend would be so costly in FY 1995. This does not provide an argument for or against those very large budgets but requires evaluation of their inevitability and sustainability.

Research training reflects the three years of the budget with a major increase in awards from 133 in 1989 to 199 in 1990 and a slight increase to 210 in 1991 for individual awards. Institutional awards are somewhat steadier with 944, 976, 966 the number of awards. Total costs for the three years goes from $22.3 million in 1989, $24.2 million in 1990, and $25.8 million in 1991. In the mechanism called "Other Research" including career awards, cooperative agreements, instrumentation grants, and small grants the numbers reflect pretty much the same story: major increases between 1989 and 1990 and respectable increases proposed for next year. The three year totals are $22.3 million, $29.3 million, and $32.5 million. $72.3 million, $77.1 million, and $81.9 million are the totals for the three years 1989-1991 in intramural support again revealing steady increases.

Drug Abuse

In the area of drug abuse the budget is somewhat different as noted earlier. This area of ADAMHA reflects the national anti-drug abuse campaign supported by the Administration. Increases follow the pattern of the mental health program except that they are larger in 1991 so that the three-year total for 1989-1991 in RPG's is $112.7 million, $148.9 million, and $172.3 million. But even here there is a small drop from $56.6 million to $52.1 million in the new/competing area whereas the continuations rise from $92.2 million to $120.1 million. In the area of research training we see major increases as well. For example, for the three years 1989-1991 the individual awards rise from $643,000 to $800,00 and $1.2 million. Institutional awards for the same years rise from $1.7 million to $3.8 million. In the other research categories we again find the same pattern. Numbers of awards for the three years are 689/826 and 906 and funding in millions of dollars $129/$169/$195. While the increases proposed for 1991 are generally less than those last year they still are very substantial.

Alcoholism

Again, the same pattern is found for research in alcoholism with a major increase last year from $65.8 million to $81.4 million and the proposal for FY 1991 -- $85.6 million. Individual training awards show the largest increases for both years, with awards in the three years rising from $142,000 to $675,000 to $905,000. Institutional awards actually drop from 1989 to 1990 and hold fairly steady in FY 1991.

RPG's rose from $65.8 to $81.4 million and then only to $85.6 million in 1991 for the same reason, since continuation grants only went up from $40.2 million to $48.6 million from 1989 to 1990 but will be $70.7 million in 1991.

If there is satisfaction in supporters of ADAMHA in this year's budget it may be less because of the specific numbers involved than the fact that a significant base is being established in these recent years, so that programs can operate with some degree of assurance over a lengthy period of time.

Chapter 8

R&D in the Department of Energy

American Association for the Advancement of Science

Susan L. Sauer

Highlights

- The Department of Energy's R&D activities would be augmented under President Bush's FY 1991 budget proposal, rising 3.1 percent to $7.4 billion.

- Atomic Energy Defense Activities, although accounting for 42.6 percent of the departmental funding pie, is held static in FY 1991. A current dollar increase of 4 percent is requested for defense-related R&D, which, in real terms, is a net reduction of 0.2 percent.

- Funding for research on conservation and renewable energy sources fares comparatively well in the Bush Administration's FY 1991 request, increasing 5.4 percent over the $277.3 million authorized by Congress this year. The FY 1990 baseline represents a 77.2 percent increase over the level Reagan requested (and Bush adopted) last January.

- The most notable increase in DOE's R&D budget is for the Superconducting Super Collider. Slated to receive an additional $100 million, the huge accelerator project would wind up with a total of $318 million in federal funds in FY 1991.

- A new appropriation account has been established entitled Environmental Restoration and Waste Management, consolidating cleanup activities previously funded within the DOE's defense programs, Nuclear Energy, and Energy Research. A 12.3 percent increase, to $206 million, is proposed for this new priority area.

INTRODUCTION

There are few surprises in the President's FY 1991 funding request for the Department of Energy (DOE). The three main legs of the R&D table -- namely defense-related activities, the general science program, and the energy program focused on longer-term R&D -- remain as unbalanced as ever, with the defense leg still the longest and the general science leg still the shortest. Indeed, Atomic Energy Defense Activities claim 42.6 percent of the R&D budget pie for DOE, and additional defense money is tucked away in the Nuclear Energy budget as well. Energy R&D programs, in contrast, shrink slightly, due primarily to a decrease in funds for the Clean Coal Technology Program. The most most significant growth in FY 1991 is realized in the General Science account, thanks to a proposed $100 million increase for the Superconducting Super Collider. Yes, big science is a big winner in the proposed budget for the new fiscal year.

Environmental restoration and waste management activities are teased out of several program areas and awarded an appropriation account all their own. Increased international attention to and awareness about our fragile environment has prompted the Administration to take note, and a Five-Year Plan is now being implemented which reflects DOE's elevated public commitment to environmental cleanup.

Funding for research into conservation and renewable energy sources, such as photovoltaics and biofuels, also makes a surprisingly strong comeback after years of financial starvation under the Reagan Administration. Historically slashed each year by the past Administration (and partially restored by the Congress), this area's budget for FY 1991 actually allows for some increase.

All told, the Administration is requesting close to $7.4 billion for R&D within the Department of Energy. The amount is 3.1 percent higher than last year's funding level, and 18 percent higher than the FY 1989 appropriation.

Details of President Bush's FY 1991 request for DOE may be found in Table II-12, and in the text that follows.

I. ENERGY SUPPLY R&D

Approximately one-fourth of the Energy Department's R&D budget for FY 1991 is designated for various activities categorized under the heading, Energy Supply. The proposed funding level for this area is a full 10 percent higher than last year's level, climbing from just under $1.7 billion in FY 1990 to nearly $1.9 billion in FY 1991. Energy Supply R&D is comprised of a number of distinct program areas which are broken out in some detail below.

Solar and Other Renewables

Solar and other renewable energy sources suffered greatly under the Reagan Administration, which contended such projects were best left to the private sector. The new Bush proposal, in contrast, includes additional funds and substantial reallocations into several priority programs, including photovoltaics and biofuels. A 25.8 percent increase in funding, including a new cost-sharing initiative, is proposed for the photovoltaics (PV) program, for a total of $43.6 million. Likewise, the biofuels program budget is beefed up significantly in the President's proposal, rising 71.9 percent to $28 million in FY 1991.

Indeed, all but three of the subprograms under the solar and other renewables category experience growth, thanks to the Bush budget proposal for FY 1991, with **Solar** R&D overall expanding 31 percent. The most impressive growth is for the Solar Energy Research Institute (up 702.5 percent); the "losers," in contrast, are proposed for wind energy systems research (reduced by 5.8 percent), solar buildings (down 20.6 percent), and ocean thermal programs (terminated altogether in FY 1991).

Geothermal Energy R&D is slated to drop slightly (1.2 percent) in FY 1991, to $17.1 million. Hard rock penetration research, and reservoir and conversion technologies assume more prominence (vis-a-vis increased funding) in the presidential request; geopressured research funding, on the other hand, is halved, and magma energy research is deferred "in order to place increased effort on hydrothermal objectives." **Hydropower**, which was zeroed out of several previous budgets, is back in the FY 1991 budget at a requested level of $1 million.

Nuclear Energy

The DOE's nuclear energy R&D budget increases 4.8 percent in the budget submission for FY 1991, for a requested total of $349 million. Percentage-wise, the greatest increases are for **Space Reactor Power Systems** and **Advanced Radioisotope Power Systems**, which climb 74.1 percent (to $54.5 million) and 53.9 percent (to $75.5 million), respectively. In the latter program account, support is provided for, among other things, two new NASA program starts -- the Comet Rendezvous Asteroid Flyby (CRAF) and Cassini missions.

Both of these nuclear R&D program areas are specifically focused on satisfying the needs of both NASA and the Department of Defense; thus, they are distinct from the purely civilian reactor development programs, namely, the **Light Water Reactors** (LWR) program (which climbs from $24.4 million in FY 1990 to $31.5 million in FY 1991), and **Advanced Reactors R&D** (which drops 20 percent to $47 million). The major thrust of the LWR program is the Advanced Light Water Reactor program element, which expands by 28 percent in FY 1991 and continues to complement industry reactor design programs. The cutback in the Advanced Reactors R&D program budget reflects general reductions in fuel cycle R&D, liquid metal reactor research, and research and test reactors.

Facilities subsume the largest chunk of the nuclear energy R&D budget for FY 1991, garnering $140.5 million. The proposed amount is $29.2 million less than last year's estimated appropriation and reflects commencement of close-out of the Fast Flux Test Facility reactor starting in FY 1990, pending congressional approval.

Magnetic Fusion

The proposed budget for magnetic fusion energy in FY 1991 is essentially the same as last year's level, rising 1.4 percent to $319.6 million. The Confinement Systems subprogram accounts for half of the total magnetic fusion budget and provides the support necessary to operate the larger experimental devises (i.e., the Tokamak Fusion Test Reactor; the Princeton Beta Experiment-M; the Alcator C-Mod, which is now under construction; the Advanced Toroidal Facility; the Doublet III-D, the Microwave Tokamak Experiment; and the Compact Ignition Tokamak, whose construction is on hold pending completion of a formal independent review of the project). The Applied Plasma Physics subprogram is of secondary importance in terms of funding and involves theoretical and experimental physics support, research on advanced fusion concepts, and large-scale computing.

Electric Energy Systems and Energy Storage

Pared back in FY 1990, the Electric Energy Systems and Energy Storage budget is fortified in FY 1991 by an increase of 32 percent. A total of $39.2 million is requested for the dual account, two-thirds of which is for Electric Energy Systems, whose foremost goal is applied high temperature superconductivity research. Beginning in FY 1991, the major programmatic emphasis for the Energy Storage program will be on generic research for the Proton Exchange Membrane fuel cell for all mobile and stationary applications. An eventual breakthrough in this area, according to agency justification material, could make electric vehicles a reality.

Biological and Environmental Research

In keeping with the rising public awareness and concern for the welfare of our planet, the President has requested a 9.5 percent increase in funding for DOE's Biological and Environmental Research activities. A total of $333 million is proposed for this area, including increases for an expanded carbon dioxide research program to quantify linkages between the rise of greenhouse gases and climate change; additional studies on chemical transport through atmospheric, terrestrial, and marine systems; ongoing research in structural biology, molecular genetics, and cell biology; continued radiobiological research; and a large chunk -- $19.9 million -- for continued efforts to develop the biological resources and technologies needed to characterize the human genome. No provision is made for funding congressionally-initiated university construction projects (the so-called "pork-barrel" projects) in FY 1991.

Basic Energy Sciences

The FY 1991 request for the Basic Energy Sciences (BES) program is up 13.8 percent, to $642.2 million, and includes support for approximately 1,400 individual research projects at national laboratories, universities, and other institutions; operational funding for seven major user facilities; and construction of advanced facilities. Funds are requested for the first time for reimbursement for the highly enriched uranium and heavy water used in the operation of the High Flux Isotope Reactor and the High Flux Beam Reactor. Additionally, an increase is requested to ensure the timely construction of the 6-7 GeV Synchrotron Radiation Source.

Of the six BES subprograms (excluding facilities), all but **Engineering and Geosciences** (which declines by 2.1 percent) and **Energy Biosciences** (cut 2.2 percent) experience growth. **Advanced Energy Projects** realize a significant gain (64.5 percent) due, in part, to an effort to rapidly transfer synchrotron radiation technology -- important for the next generation of computer chips -- from DOE laboratories to the semiconductor industry. The **Materials and Chemical Sciences** account for the bulk of BES funding, garnering $222 million (an 11.7 percent increase over the FY 1990 level) and $150.5 million (a 7.3 percent increase) of the program budget, respectively. **Applied Mathematical Sciences** also shows growth -- an increase of 9.8 percent -- in the presidential submission for FY 1991.

Energy Research Analyses

The Energy Research Analyses program provides for the capability for independent technical assessments of the DOE's energy R&D programs. A total of $3.7 million is budgeted for this activity in FY 1991, down 2.6 percent from last year's level. Most of the support goes toward assessments in Fossil Energy, Conservation and Solar Renewables, and Energy Research areas. A small share of support is for acid precipitation assessments.

University Research Support and Instrumentation

The University and Science Education program within DOE is, according to the Administration, due a 19.7 percent increase in funding, for a total of $29.8 million in FY

1991. A chunk of the proposed increase is to provide for program needs for uranium enrichment and fuel conversion costs. Funds are also included to initiate a precollege mathematics and science education program at DOE labs, and to establish partnerships designed to revitalize the math/science curriculum in targeted school districts. A $6 million savings is assumed (again) through the proposed discontinuation of the nuclear engineering research and education program. The Energy Department's University Research Instrumentation program budget is held level at $5 million, enough to support 18-20 instrumentation awards.

II. FOSSIL ENERGY R&D

Fossil energy R&D is clipped at the knees in FY 1991. Last year's program level is estimated to be $344.7 million; the proposed FY 1991 funding level is half that, or $167.1 million. According to program guidelines, one of the primary goals of all the applied research areas in Fossil Energy is "to effectively transfer technology from federal and university laboratories to the U.S. private industry." In this vein, a new consortium approach is proposed which includes $17 million for an integrated initiative to competitively support oil and gas recovery and geoscience research with industry, states, and leading universities.

The Administration sites a number of program shifts in emphasis from past Administration budgets, namely, a recognition of the problems of global warming, and of the need to ensure the strategic security of liquid and gaseous fuel lines. With this as justification, the President has proposed slashing the largest fossil R&D component, **Coal**, by nearly 60 percent in FY 1991. Only advanced research and technology development escapes the budget ax unscathed; all other program elements are cut signficantly, and the $40 million magnetohydrodynamics program is zeroed out altogether.

Although not nearly as drastic, **Gas** research also incurs a cut -- of 5.2 percent -- under the new proposed budget. **Petroleum**, on the other hand, realizes an incremental (2 percent) gain in FY 1991; however, while funding to develop advanced technology for extracting and processing petroleum would more than triple, oil-shale research would be all but eliminated.

III. ENERGY CONSERVATION

Last year's budget proposal included just $74.9 million, or half of the then-current level, for activities relating to energy conservation. This fiscal year, in stark contrast, the Administration appears to be holding true to its vow of increasing its commitment to conservation, and has requested $163.6 million (6.5 percent less than the estimated FY 1990 level). Industrial, transportation, and multisector energy conservation efforts sustain cuts of 10.7 percent, 8.4 percent, and 3.5 percent, respectively, while funding for buildings and community systems increases by 19.7 percent. Facilities, unfunded in FY 1990, receive a recommended appropriation of $4 million in FY 1991.

IV. GENERAL SCIENCE AND RESEARCH

General Science activities consist of three major programs: High Energy Physics, Nuclear Physics, and the Superconducting Super Collider (SSC), all of which are concerned with basic research into the fundamental forces of nature. General Science is the third largest account within DOE's R&D budget, behind Atomic Energy Defense Activities and Energy Supply R&D, and is slated to receive a 16 percent increase in FY 1991, for a total of nearly $1.3 billion. The major programs all realize growth; however, the SSC is the biggest winner, increasing by $100 million.

High Energy Physics

High Energy Physics accounts for half of the General Science R&D budget, claiming $621.2 million in FY 1991 under the President's proposal. By way of comparison, last year's budget authority is estimated at $582.1 million. Priority is accorded to strong facilities operations and research programs at the three DOE supported high energy physics accelerator centers: Fermi National Accelerator Laboratory (Fermilab), Stanford Linear Accelerator Center (SLAC), and Brookhaven National Laboratory (BNL). To these is being added the Superconducting Super Collider (SSC), which is included in a separate FY 1991 budget category.

The strategy for the overall High Energy Physics program for FY 1991 revolves around three key factors: (1) operation of the new research capabilities of the Stanford

Linear Collider (SLC) and the Tevatron accelerator/collider; (2) continued effective participation of university scientists; and (3) pursuit of long-range accelerator and detector R&D studies.

Superconducting Super Collider

The biggest news, perhaps, as far as the DOE's R&D budget is concerned, is the federal commitment to funding the Superconducting Super Collider. A total of $317.9 is provided for the SSC in FY 1991, an increase of almost $100 million over the previous year's level and including $168.9 million for construction. The budget strongly supports work to complete the design, development and testing of the superconducting dipole magnets that will propel proton beams around the 53-mile long tunnel.

Originally estimated to cost $4.4 billion, the accelerator, according to many observers, may well sport a pricetag that is $1 billion to $2 billion more than the $5.9 billion total currently cited by DOE. The host state of Texas has pledged $1 million in cash payments to the project (an estimated $200 million in FY 1991), and agreements with foreign contributors are being negotiated. The 10-year design and construction schedule is maintained in the FY 1991 budget.

Nuclear Physics

Understanding the interactions, properties, and structures of nuclei and nuclear matter is the central objective of the Nuclear Physics program. The Administration's FY 1991 proposal provides $330.7 million for R&D in this area, including additional support for medium energy and heavy ion nuclear physics research and operations. Program emphases include continued construction and support of the Continuous Electron Beam Accelerator Facility (CEBAF), and start-up construction of the Relativistic Heavy Ion Collider (RHIC) project.

V. ATOMIC ENERGY DEFENSE ACTIVITIES

Atomic Energy Defense Activities (AEDA) represents the largest slice of the full DOE R&D funding pie, collecting just over $3.1 billion in the President's FY 1991 request.

Growth in this area, albeit predictable, has slowed somewhat in recent years; in fact, the AEDA budget request is held close to the rate of inflation, which, in 1991, is forecast at about 4.2 percent. Even so, AEDA will command 42.6 percent of the Energy Department's R&D budget in FY 1991 if Congress approves the request.

Nearly two-thirds of the AEDA total -- some $1.9 billion -- is applied toward **Weapons Research, Development, and Testing**, which provides "the primary scientific and technological underpinning for United States nuclear deterence." Funds here will provide for the Energy Department's core nuclear weapons RD&T complex and for research on the Inertial Fusion program. **Naval Reactors Development**, responsible for carrying out nuclear propulsion development work for the U.S. Navy, is budgeted at $638 million (an increase of 1.4 percent), while **Materials Production** support is cut 2.8 percent to $226.2 million.

Funding for **Verification and Control Technology** is reduced by 11.7 percent, to $50.5 million; **Nuclear Safeguards and Security** is held essentially static but makes allowances to provide for strengthened protection against insider threats. The AEDA subprogram due to increase most significantly in FY 1991 is **New Production Reactors**, climbing from $206.3 million in FY 1990 to $311.2 million requested for FY 1991.

VI. URANIUM ENRICHMENT

The principle objective of the Atomic Vapor Laser Isotope Separation (AVLIS) program, DOE's uranium enrichment R&D activity, is to "develop an advanced technology option that can enrich uranium at a cost significantly less than the production costs for gaseous diffusion plants and of foreign competitors." Focused on demonstrating the laser enrichment technology by the end of FY 1992, the AVLIS program is slated to receive $154.5 million in FY 1991, 16.8 percent more than the estimated budget authority for FY 1990.

VII. CLEAN COAL TECHNOLOGY

Funding for the Clean Coal Technology/Innovative Clean

Coal Technology program, the federal government's principal activity in the area of improving environmental performance and utilization efficiency of coal, is trimmed by almost 19 percent in FY 1991, to $431 million. The $100.5 million reduction is attributed to the fact that a number of new technology demonstration projects funded in previous years have moved into the construction phase. The selection and negotiation of projects for the fourth round solicitation gets underway in FY 1991.

VIII. ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT

The Administration's FY 1991 budget request for DOE includes a new, single appropriation account entitled Environmental Restoration and Waste Management, which consolidates cleanup activities previously funded within the department's Defense programs, Nuclear Energy, and Energy Research. Concerned about the DOE's serious environmental cleanup problems, Secretary Watkins, in March 1989, directed the preparation of a Five-Year Plan encompassing four program activities: corrective activities, environmental restoration, waste management operations, and applied R&D. The plan, published in August, 1989, is the cornerstone of the Department's long-term environmental cleanup strategy.

A total of $206 million is requested for this consolidated account in FY 1991, up 18.9 percent from last year's level and 297.7 percent from the FY 1989 appropriation. All programmatic areas realize increases; however, the most significant gain is in the area of waste operations, particularly the treatment, storage, and disposal of all radioactive, hazardous, mixed, or sanitary waste.

Chapter 9

NASA in the FY 1991 Budget

American Institute of Aeronautics and Astronautics

Joanne Padron

Highlights

- The proposed FY 1991 budget for NASA is $15.125 billion. This is $2.828 billion higher than the FY 1990 current estimate, reflecting a 23 percent increase. This is the largest proportional increase in this fiscal year of any major federal agency; however, it is unlikely that it will pass Congress unchallenged.

- NASA is proposing to initiate a major long-term program entitled the Human Exploration Initiative in the FY 1991 budget. The proposed program reflects President Bush's National Space Policy to expand human presence in space. The proposed budget supports two new robotic missions -- the Lunar Observer and Lifesat -- and increases the space technology base to begin the exploration initiative.

- A second major program NASA has proposed to initiate in FY 1991 is the Earth Observing System (EOS). EOS is the first major step in NASA's Mission to Planet Earth program and will provide long-term environmental data, obtained from polar orbiting platforms.

- The proposed Space Station budget estimate is $2.451 billion, an increase of 40 percent from the current estimate of $1.749 billion. Space Station Freedom underwent a major replanning effort in FY 1990 due to budgetary cuts of $300 million. Some subsystems have been reconfigured or deferred, with permanent manned capability rescheduled for mid-1997. It is anticipated that the Space Station budget will be the first item challenged in Congress.

- High-Speed Research was increased to $44 million in the FY 1991 budget to continue development studies for a High-Speed Civil Transport (HSCT). The HSCT is an aircraft concept capable of flying at supersonic or hypersonic speeds.
- The NASA civil service manpower ceiling will be increased by 711 to 24,466. This proposed increase in the number of civil servants is required to meet the increased workload associated with the EOS program and Space Station Freedom.

Proposed FY 1991 NASA Budget

The proposed NASA budget for FY 1991 is $15.125 billion, an increase of $2.828 billion above the FY 1990 current estimate of $12.296 billion. This represents an increase of 23 percent, the largest proportional increase of any major agency. However, the proposed NASA budget only represents 1.09 percent of the total FY 1991 federal budget.

The biggest increases in the NASA budget occurred in the following two categories:

- Research and Development -- from $5.246 billion in FY 1990 to $7.074 billion in FY 1991, an increase of $1.828 billion, and
- Space Flight, Control and Data Communications -- from $4.555 billion in FY 1990 to $5.289 billion in FY 1991, an increase of $734 million.

In his presentation of the proposed budget, NASA Administrator, Richard Truly stated that the budget demonstrated the "Administration's continued strong support for NASA and the civil space program."

Research and Development

NASA's program of research and development is concerned with "extending our knowledge of the Earth, its space environment, and the universe; expanding the technology for practical applications of space technology; developing and improving manned and unmanned space vehicles; and assuring continued development of the long-term aeronautics and space research and technology necessary to accomplish national goals."

Human Exploration Initiative

On the anniversary of the Apollo Moon landing, President Bush presented a long-term national goal for human exploration of space. In his speech the President stated that the first step is to complete Space Station Freedom in the 1990's, next, to return to the Moon, this time to stay. And last, to journey on to Mars.

NASA's response to this goal is the new start of a program entitled the Human Exploration Initiative (HEI). An increase in funding to support this program has been approved by the Administration in a number of areas, reflecting a decision to:

1) increase the pace of exploration-related technology developments;

2) increase the science return from the Mars Observer mission; and

3) initiate the development of two Space Science missions, the Lunar Observer and Lifesat.

Specific budget augmentations in FY 1991 amounted to $188 million.

Space Station Freedom

With the definition of a long-term national goal of expanding human presence in space, NASA and the administration have emphasized Space Station Freedom as the "cornerstone" for any future exploration missions. The FY 1991 funding requested for this program is $2.451 billion, reflecting an increase of $701.4 million (40 percent) from FY 1990. NASA is requesting multi-year appropriations for the Station in order to stabilize the program. The multi-year budget laid out is $2.9 billion in FY 1992 and $3.03 billion in FY 1993.

Even with the increased emphasis on the importance of the Station, it is still a politically hot topic. Freedom underwent a major replanning effort in FY 1990 due to cuts by Congress of $300 million, with the reconfiguration of some subsystem elements and the deferral of other elements to later dates. First element launch is still scheduled for March 1995, with man-tended capability rescheduled to third quarter 1996, permanent manned capability to mid-1997 and assembly complete to late 1999.

Management of the polar-orbiting platforms is being transferred out of the Office of Space Station to the Office of Space Science and Applications, since the platforms are now being utilized as part of EOS. Funding for the development of the platforms will now be included in the Space Science and Applications program beginning FY 1991.

Space Transportation

This area received a substantial increase from $562 million to $773 million in FY 1991 (38 percent). The biggest increase was in the Advanced Launch System (ALS) program, a joint NASA/Air Force project studying heavy-lift launch concepts. Funding for NASA managed elements was deleted in the FY 1990 appropriations legislation and transferred to DoD's budget request. A budget request of $53.9 million in Advanced Transportation Technology has been proposed by NASA in FY 1991. The ALS effort will be a critical element of the Human Exploration Initiative.

Space Science and Applications

This area is concerned with advancing our knowledge of the Earth, the solar system and the universe using automated spacecraft. It also explores the fields of Life Sciences and Materials Processing. Funding requested in this area was increased $477 million (24 percent) to $2.481 billion. The programs are divided into seven subcategories:

- Physics and Astronomy -- increased by $123 million to $985 million. This includes funding augmentation for the continued development of the Advanced X-Ray Facility, the third "Great Observatory."

- Life Sciences -- increased over 50 percent to $163 million. This includes increased funding for continued mission studies of Lifesat, a reusable re-entry satellite for life sciences research. This reflects NASA's interest in expanding our knowledge of the effects of weightlessness, information which will be crucial in the implementation of the Human Exploration Initiative.

- Planetary Exploration -- increased $93 million (24 percent) to $485.2 million. Funding for the Comet Rendezvous Asteroid Flyby (CRAF)/Cassini grew significantly from $29.5 million in FY 1990 to $148 million in FY 1991. Development of the tentative instrument payload will begin in FY 1991. The CRAF/Cassini mission will provide invaluable data on the evolution of our solar system by observing Saturn and the comet Kopff.

Funding was also requested to support mission studies for the Lunar Observer program which is scheduled to be a new start in FY 1992. The Lunar Observer program will utilize robotic spacecraft to observe the topography, and surface composition of the Moon, information necessary to establish an ideal location for a lunar outpost.

- Earth Science and Applications -- was increased approximately 50 percent to $661.5 million. This increase reflects NASA's interest in understanding the Earth as an integrated system and the environmental issues we face, such as global warming and ozone depletion. The budget request includes development of a series of Earth Probes and a new start for the Earth Observing System program.

  The Earth Observing System (EOS) is a key element of the U.S. Global Change Research program and NASA's Mission to Planet Earth (MPE). EOS utilizes a series of three polar orbiting platforms to study the Earth's atmosphere, oceans, and land surface. In FY 1991 $235 million has been requested to begin development of EOS-A, which will observe land mass; and to continue technology development of EOS-B, which will focus on the Earth's oceans and atmosphere. It has been estimated by NASA that the total cost for this program will be $17 billion by the year 2000.

Another new initiative is the Earth Probes program, which will complement EOS by addressing specific problems in Earth science. Funding in this area is included for items such as the Total Ozone Mapping Spectrometer, scheduled to be launched in 1993, and the Tropical Rainfall Mapping Mission.

- Materials Processing in Space -- decreased by $1.7 million to $97.3 million.

- Communications -- decreased by $25 million to $52 million (32 percent). Congress reinstated funds for the Advanced Communications Technology Satellite (ACTS) in FY 1990 and NASA has requested continued support in FY 1991.

- Information Systems -- increased by $8.6 million to $36.8 million. This program provides advanced data systems to support NASA's space science and applications flight and research projects. It is anticipated that the implementation of HEI and MPE will significantly increase the amount of scientific data returned. Therefore, data management will become a crucial element in the support of these projects.

Commercial Programs

Commercial Programs grew significantly, increasing from $56.5 million (79 percent) to $101 million in FY 1991. This area is divided into two subcategories: Technology Utilization, which deals with technology transfer to the private sector; and Commercial Use of Space, which develops opportunities for the expansion of U.S. private sector investment and involvement in civil space activities.

Commercial Use of Space received the largest portion, increasing $43.8 million (133 percent) to $76.6 million. This reflects NASA's interest in providing enhanced and increased opportunities for commercial payloads requiring a microgravity environment. Funding will also support the lease of a commercially provided payload module which will provide pressurized man-tended payload capability onboard the Shuttle.

Aeronautical and Space Research and Technology

Requested funding in this area was increased from $794.7 million in FY 1990 to $1.127 billion in FY 1991. This area is divided into four categories:

- Aeronautical Research and Technology -- increased $62.2 million (14 percent) to $512 million. This area addresses the critical issues associated with maintaining U.S. preeminence in civil and military aviation.

  High-Speed Research was increased by $19.5 million to $44 million. Funding in this area will be used to continue exploring issues critical to the development of a future High-Speed Civil Transport (HSCT). Environmental issues (such as atmospheric impact, airport noise, and sonic boom) will also continue to be addressed. The HSCT program is studying the feasibility of a 300-passenger transport capable of flying at supersonic or hypersonic speeds.

- Transatmospheric Research and Technology -- increased by $59.9 million to $119 million (102 percent). This is a joint NASA/DoD research and technology program for the National Aero-Space Plane (NASP). NASP is an experimental single-stage-to-orbit vehicle using airbreathing propulsion. Funding has been requested to continue the current phase of technology development for this program.

- Space Research and Technology -- increased $210 million (73 percent) to $495 million in FY 1991. This significant increase reflects NASA's interest in replenishing the "technology bank" that has been depleted since the Apollo program. The goal of this area is to provide advanced, enabling technologies for future space missions, such as HEI.

  Two of these programs are the Civil Space Technology Initiative (CSTI) and the Exploration Technology program. CSTI will develop critical technologies for efficient, reliable access to space. Funding has been increased from $123.8 million in FY 1990 to $171 million in FY 1991.

The Exploration Technology Program (formerly Pathfinder) advances critical technologies in the areas of manned and robotic missions to expand human presence beyond Earth's orbit. This program increased significantly: from only $26.9 million in FY 1990 to $179.4 million in FY 1991 (an increase of 566 percent).

- Exploration Mission Studies is a new budget line item for FY 1991 with funding requested at $37 million. Prior year funding for any exploration-related mission studies was listed within individual program budgets accordingly. The goal of this area is to continue mission studies in areas such as transportation systems, propulsion and power systems, life support requirements, and robotics.

Space Flight, Control and Data Communications

This area is concerned with Shuttle production and operational support, and provides tracking and communication systems required for all NASA flight projects. Funding in this area was increased by $733.7 million to $5.289 billion in FY 1991.

There are ten Shuttle flights scheduled in FY 1991 with eleven scheduled for FY 1992 and FY 1993, and twelve scheduled for FY 94.

Civil Service Workforce

NASA's civil service workforce will be increased by 711 to a total of 24,466 in FY 1991. This proposed increase in the number of civil servants is required to meet the increased workload associated with the Earth Observing System program, and Space Station Freedom.

Chapter 10

R&D in the Department of Agriculture

National Association of State Universities and Land-Grant Colleges

James W. Cowan

The FY 1991 Research and Development budget request for the Department of Agriculture is $1,224.5 million. This figure is 7 percent above the FY 1990 level of $1.141 million. The totals by agency for 1990 and for the 1991 request in millions of dollars are:

	FY1990	FY1991
Agricultural Research Service (ARS)	601.6	661.1
Cooperative State Research Service (CSRS)	340.5	346.9
Economic Research Service (ERS)	50.9	56.5
Forest Service (FS)	148.0	160.0
Total R&D, USDA	1,141.0	1,224.5

Below are more details on the various agencies and their respective 1990 appropriations and 1991 request.

Agricultural Research Service (ARS)

The proposed budget for ARS, the primary research agency in the USDA, is $601.6 million, or about 10 percent more than 1990. ARS will continue its emphasis on Soil and Water Conservation, recognizing the need to develop "a sound scientific base to provide advanced technical assistance and education to producers to manage and conserve soil and water resources." There is a recommended increase of $10.8 million for food safety issues such as bacterial contamination at the farm level to drug and pesticide residues. In addition, the ARS budget includes a $3.7 million increase for a joint program of plant genome mapping to be conducted jointly with CSRS through the National Research Initiative.

ARS RESEARCH PROGRAMS
(in millions of dollars)

Program	FY1990	FY1991
Soil and Water Conservation	73.6	89.0
Plant Sciences	216.6	229.8
Animal Sciences	99.8	104.1
Commodity Conversion/ Delivery	110.1	122.0
Human Nutrition	47.9	48.0
Integration of Agricultural Systems	12.1	12.2
Buildings and Facilities	10.7	32.6
Repair and Maintenance	24.9	17.4
Contingency	0.9	0.9
Trust Fund	5.0	5.0

Cooperative State Research Service (CSRS)

CSRS administers federal funds provided for research at the state agricultural experiment stations and other eligible institutions. The agency also participates in the nationwide system of research planning and coordination. The proposed budget for CSRS for 1991 is $340.5 million, about 2 percent more than 1990.

The USDA has introduced in its 1991 budget a National Research Initiative on Agriculture, Food and Environment (NRI) of $100 million. The Administration proposes that this amount be increased $50 million annually up to $300 million provided that funds are awarded competitively and not earmarked for special interest purposes. The NRI comes as a response to the 1989 report of the National Academy of Science's Board on Agriculture which outlines "a course of action that will resolve key problems in agriculture, advance the sciences that undergird the nation's agriculture and the quality of U.S. natural resources, and enhance the nation's well-being." The NRI consists of 4 categories for 1991: Natural Resources/ Environment; Nutrition, Food Quality and Health; Plant Systems; and Animal Systems. Several currently funded line items would be folded into one of the 4 categories of the NRI. They include: Animal Health (sec. 1414); Aquaculture Research (General); Rangeland (PL 95-113); and the competitive grants for Plant Sciences, Human Nutrition, Animal Sciences, Biotechnology, Basic Pest Sciences, Stratospheric Ozone/Global Change; and Forestry. Funds would be awarded on a competitive basis to both individual researchers and multi-disciplinary teams. Universities, federal labs, private and nonprofit organizations would be eligible to seek funding. Ten percent of the funding would be directed to small institutions for the development of their research capabilities.

CSRS RESEARCH PROGRAMS
(in millions of dollars)

Program	FY1990	FY1991
Hatch Act	155.1	158.5
Cooperative Forestry Formula	17.3	13.0
1890 and Tuskegee	25.0	26.2
Animal Health (sec. 1433)	5.4	0.0

CSRS RESEARCH PROGRAMS (cont'd)
(in millions of dollars

Program	FY1990	FY1991
P.L. 89-106		
Competitive Research Grants	42.5	*
National Research Initiative		
Plant Systems	0.0	50.0
Animal Systems	0.0	30.0
Nutrition, Food Quality and Health	0.0	5.0
Natural Resources and Environment	0.0	15.0
Special Grants	56.3	25.6
Higher Education	5.9	6.0
Morrill-Nelson Act	2.8	0.0
Critical Agriculture Materials Act	5.3	0.0
Aquaculture Research Centers	3.7	0.0
Alternative Crops Research	0.3	0.9
Forestry Competitive Grants	3.9	*
Low-input/sustainable agriculture	4.4	4.5
International Trade Centers	3.1	0.0
Agriculture Productivity Research	4.5	0.0
Federal Administration	7.9	1.2
Buildings and Facilities	45.1	0.0

* To be incorporated into the National Research Initiative.

More details on the CSRS program are:

P.L. 89-106 Grants/Special and Competitive

P.L. 89-106: The "Research Grants Act," initially approved by Congress in 1965 and subsequently amended, authorizes two key programs: a competitive grants program, open to all, and a special grants program targeted to eligible cooperative institutions.

There are two general types of grants in the special grants programs of CSRS: national or regional programs developed to meet national needs and complement other research programs; and special problem grants which address acute problems needing a short-term infusion of funds, either until the problem is solved or until activities are incorporated into base research efforts.

SPECIAL RESEARCH GRANTS
(in million of dollars)

Continuing National Research Programs	FY 1990	FY 1991
Integrated Pest Management	2.9	4.0
Pesticide Clearance	2.0	3.0
Minor Use Animal Drug	.2	.3
Pesticide Impact Assessment	2.4	2.9
Rural Development Centers	.5	0.0
Animal Health Research	.5	*
Aquaculture Research	.5	*
Tropical and Subtropical Research	3.3	0.0
Acid Precipitation	.7	0.0
Biological Impact Assessment	.1	.3
Special Problem Grants	31.0	0.0

* To be incorporated into the National Research Initiative.

COMPETITIVE RESEARCH GRANTS
(in millions of dollars)

Continuing National Research Programs	FY 1990	FY 1991
Plant Science	7.6	*
Human Nutrition	1.5	*
Animal Science	4.9	*
Biotechnology (animal and plant)	19.0	*
Pest Science	2.0	*

COMPETITIVE RESEARCH GRANTS (cont'd)
(in millions of dollars)

Program	FY1990	FY1991
Stratospheric Ozone - Global Change	3.7	*
Plant Science Centers	0.0	*

* To be incorporated into the National Research Initiative.

Economic Research Service (ERS)

ERS performs economic and other social science research, outlook forecasting, and policy analysis related to U.S. and international agriculture, food, production resources, and rural America. The FY 1991 budget proposal of $56.6 million is an increase over the 1990 level of $50.9 million. The Administration supports $1.6 million for a Food Safety Initiative which would "provide analytic support for USDA food safety and pesticide assessment activities and the evaluation of the costs and benefits of alternative public and private food safety control strategies and will provide assessment of the impact of pesticide regulation and residue control programs on the safety of the public food supply." ERS is requesting a $2.1 million increase to expand water quality-related data collection and economic and policy analysis in response to the need of USDA and other federal agencies for research, education, technical assistance, and pesticide benefit-cost and risk assessments. This increase for ongoing activities would continue response to the ongoing national concern for conservation and purity of the water supply.

Forest Service (Research)

Research is conducted and disseminated through eight regional forest experiment stations and the Forest Products Laboratory and includes both in-house and extramural programs. The FY 1991 budget request of $150.2 million remains at essentially the same level as the FY 1990 current estimate. The Forest Service has identified several high priority issues for intensive work: Global Climate Change; Water Quality; Threatened and Endangered Species; Rural Development; Catastrophic Wildfires; and Southern Forest Productivity.

Chapter 11

R&D in the Environmental Protection Agency

American Association for the Advancement of Science

Kathleen M. Gramp

Highlights

- As proposed by the President, EPA's R&D budget would total $468.8 million in FY 1991, $44.8 million (or 10.6 percent) more than was appropriated for the current year. The budget provides $449.6 million for the conduct of R&D (up $25.5 million, or 6 percent) and $19.2 million for facilities (compared with zero facility funding in FY 1990).

- The R&D proposal has winners and losers. EPA would add a total of $52.5 million for some programs, but cut a total of $27 million from others. The biggest gainers are multi-media and air quality research. Superfund and hazardous waste R&D are lower priority. Funding for acid rain studies would fall by $17.9 million (or 57 percent), because EPA will have completed its national assessment in 1990.

- There are several new initiatives woven into the FY 1991 request. About $11 million has been earmarked for research on all facets of "pollution prevention." The air quality program will be studying alternative fuels, in response to new statutory mandates. Several programs are developing remote sensing devices for measuring and monitoring pollutants.

- Starting in 1991, interdisciplinary, multi-media research would be the largest component of the R&D program. EPA recommends a $26.1 million (or 31 percent) increase for these initiatives.

- A rising share of the air quality budget would be dedicated to global climate research. Close to two-thirds of the money added for air research would be for the stratospheric modification program. Funding for all air R&D, including global change, would go up by $17.1 million (or 22 percent).

- Other R&D programs slated for above-inflation increases are pesticides (up $2.8 million, 22 percent), radiation (up $0.4 million, or 12 percent), water quality (up $2.2 million or 8 percent), toxic substances (up $1.9 million or 7 percent) and drinking water (up $1.1 million or 5 percent).

- The two programs dealing with hazardous materials -- Superfund and hazardous wastes -- would see funding fall by a combined $9.1 million (or by 8 percent and 6 percent respectively).

R&D Budget Overview

EPA's research programs provide the scientific basis for the agency's regulatory and management actions. For this purpose, the President has requested a total of $468.8 million for FY 1991.

The 10.6 percent gain proposed for R&D is proportionately smaller than most of the other parts of the agency's budget. Funding for "Superfund" would go up by 13 percent (to $1.7 billion). Operating programs other than R&D would receive 12 percent more money than in FY 1990 (or $1.7 billion, excluding R&D).

On the other hand, R&D fares better than the agency as a whole. The increases are largely offset by a steep reduction in the federal investment in wastewater treatment plants. As the government shifts from grants to state revolving funds, the construction budget would fall by 20 percent (to $1.6 billion). Thus, overall, the President is asking for less than a one percent increase in EPA's budget (or $5.6 billion).

About 60 percent of the $468.8 million R&D budget supports applied research. Basic research, however, is increasing faster than at any other federal agency. By FY 1991, 22 percent (or $99 million) of EPA's R&D would be used for basic research, compared to 13 percent (or $52 million) in FY 1989.

Appropriations for EPA's R&D are split among four accounts: "Research and Development" (which funds most extramural activities), "Salaries and Expenses" (which covers most intramural research), and the Superfund and Leaking Underground Storage Tank trust fund accounts (which include extramural and intramural research for their respective programs). Table II-16 and II-17 show how the R&D funds would be allocated by medium (air, water, pesticides, etc.), and by category (environmental engineering, health effects, monitoring, etc.).

The cross-cut by medium shows that 24 percent of the R&D budget would be devoted to interdisciplinary research, 24 percent to hazardous materials (Superfund cleanup and hazardous waste controls), 23 percent to air-related problems (e.g., air quality and acid rain), 11 percent to water-related issues, and 9 percent to toxic materials and pesticides.

When viewed by category, engineering R&D absorbs 18 percent of the R&D budget, interdisciplinary research 17 percent, and monitoring, health, and environmental processes each receive about 12 percent of the total.

Global Climate Change (Air Quality Research)

Out of the more than $1 billion proposed by the President for global change research, EPA would receive $26.1 million, or less than 3 percent of the total. Though small in comparison to other agencies, this request represents nearly a 70 percent increase (or $10 million) over the FY 1990 effort.

Two issues dominate EPA's research effort: stratospheric ozone depletion and global warming.

Researchers would analyze the impacts of depleting the stratospheric ozone layer, and alternatives for chemicals that deplete it. Studies would target the effects of UV-B radiation on human immunosuppression, wetland rice ecosystems, the marine food web, and biogeochemical cycling. On the technology side, EPA would evaluate product alternatives to cloroflorohydrocarbons (CFCs) and halons, especially as used in refrigerators, fire extinguishers, and insulation. Another goal is to find ways of reducing emissions of these and other chemicals.

The budget recommends expanding research on the magnitude and impact of global warming. One goal is to better understand factors affecting atmospheric trace gases and the surface energy balance. Specific studies would investigate the effects of plant canopies on organic trace emissions, of terrestrial ecosystems on carbon fluxes, and of human activity on certain ozone concentrations.

Also on the agenda are reports on the causes and effects of regional climate variation, including biological and physical factors. EPA plans to analyze the effects of climate change on a variety of ecosystems, including forests, semi-arid regions, agroecosystems, and marine, freshwater, and related ecosystems.

Other Air Quality Research

EPA has asked for $68.9 million for its other air quality R&D, which is $6.5 million (or 10 percent) above the current level.

Some of this increase would support research on alternative fuels, in compliance with the mandates in the Alternative Fuels Act of 1988. The agency needs techniques for measuring and characterizing the emissions from all stages of alternative fuel production and use. Studies quantifying human exposure to benzene and other volatile organic pollutants would be used to model exposure to methanol and other new fuels.

EPA plans to expand research on ozone's formation and effects. The failure of many jurisdictions to meet federal ozone standards has underscored the need for more research on ozone transport and fate. Given the need to improve methods of measuring ambient levels of inhalable particulates (e.g., ozone and acid aerosols), EPA wants to develop remote sensing techniques, including the Light Induced Detection and Ranging technology. In addition, health studies would test the link between chronic lung disease and long-term exposure to urban ozone. Ecological research would determine whether a new ozone standard is needed to protect forest species. EPA also plans to study the characteristics and effects of acid aerosols. The budget calls for a new, integrated study of acid aerosol formation and neutralization. Methods for measuring and characterizing these acids would be improved. Health studies would investigate the effects of inhaled acid aerosols on humans and animals.

To support its Integrated Air Cancer Project (IACP), EPA would develop models on the dosimetry of volatile organic compounds in humans. Methods for detecting indoor and outdoor hazardous air pollutants (HAPs) would be improved. Other studies would examine the atmospheric transformation and fate of volatile, aerosol, and other materials.

EPA also would assess the risks associated with several indoor air pollutants and biocontaminants. Studies would be done on the health effects of "sick buildings," environmental tobacco smoke, and emissions from certain indoor appliances. Methods for testing the performance of air cleaners should be completed in FY 1991.

Acid Rain (Energy) Research

Now that EPA has completed the final "National Acid Precipitation Assessment Program," spending on acid rain issues will be cut in half. Congress will receive the final report in FY 1990.

The $14.3 million request for FY 1991 is $17.9 million less than was approved for the current year. Approximately $10.6 million of this total would be used to improve the techniques used for estimating emissions, modeling atmospheric processes, testing control strategies, and monitoring acid deposition.

The budget targets the remaining $3.7 million for demonstrating a variety of technologies, including the tangentially-fired boiler LIMB project, the ADVACATE process (for reactivating sorbents), and innovative SOx, NOx technologies.

Water Quality

Worries about oil spills and wetlands have prompted a $2.2 million (or 8 percent) increase in the proposed budget for water quality R&D. These additions bring the FY 1991 request up to $28.9 million.

The massive cleanup of Valdez, Alaska, has put oil spill research back on the agenda to the tune of $2 million in FY 1991 (up $1 million, double last year's level). EPA's efforts will concentrate on biological, chemical and thermal techniques for oil spill cleanup and prevention. Studies of "physical" cleanup methods remain the purview of the US Coast Guard.

EPA would expand ecological research on wetlands, in keeping with the Administration's policy of "no net loss" of wetlands. Studies would further define their effect on water quality, the impacts of wetland conversion, and ways to restore or create them. Research on sediment quality would complement the wetlands effort, by providing criteria for measuring contaminants and assessing related risks.

Coastal and marine ecosystems remain a research priority. The agency would study the impacts of waste disposal in coastal waters, and develop protocols for monitoring viruses and bacteria in shellfish and fish. The Great Lakes program would continue to emphasize in-place pollutants and mass balance studies.

Finally, the agency would investigate a variety of effluent-related concerns. Studies would be done on toxic pollutants in industrial wastewater, on the health effects of chemicals in sludge and wastewater, and on technologies for improving the effectiveness of publicly owned systems.

Drinking Water Research

EPA has a mandate to protect drinking water supplies both underground and at the tap. The $22.8 million proposed for drinking water research is 5 percent above the FY 1990 appropriation, enough to cover inflation costs.

Many municipalities soon will be adding new disinfectants to their water supplies as substitutes for chlorine. Tests of these substitutes -- especially ozone and chloramine, the most commonly used alternatives -- would examine the toxicological effects of their byproducts. Health studies would investigate the link between disinfectants and chronic health problems. Microbial deterioration in distribution systems also would be evaluated.

EPA seeks to continue research on ways to monitor and protect groundwater supplies. The agency is interested in methods for extracting samples, continuous monitoring, removing contaminants (e.g., pesticides, radionulides, and volatile organic compounds), and restoring acquifers through in situ techniques.

Hazardous Waste Research

EPA is asking for more money to regulate hazardous substances, but less for related R&D. Repeating past trends, the agency recommends cutting funding for hazardous waste research by $2.6 million (or 6 percent compared to FY 1990), bringing the total down to $41.2 million.

The drop is attributed to past progress on such issues as landfills, leaking underground storage tanks, and solar technologies for treating wastes. EPA wants to halt funding for two research centers (the New Orleans Waste Management Center and the Center for Environmental Management at Tufts University), on the assumption that both could be self-supporting.

EPA would continue studies on waste combustion and incineration. By FY 1991, the Municipal Innovative Technology Evaluation (MITE) program expects to be able to demonstrate full or nearly full scale equipment. Incinerator studies would focus on air pollution control devices and ash disposal and utilization. As part of its health assessment of municipal combustion, the agency would test the relationship between health problems and the source of the contaminants (e.g., soil, water, chemicals).

Proposals to improve subsurface monitoring dovetail with other groundwater research. EPA hopes that remote sensing devices will help in enforcing permits and monitoring spills. Automated methods for tracking subsurface plume migration would be evaluated for their use in tracking the migration of wastes toward groundwater. Other monitoring goals include developing better methods for detecting pollutants at disposal sites, especially toxics in soils and sediments and organics in the air.

The budget includes $2.4 million for research on pollution prevention, but does not specify the nature of the projects.

Superfund Research

R&D on another angle of the hazardous waste problem -- cleanup of "Superfund" sites -- also gets cut under the President's budget. The $71.8 million requested for these projects falls short of the FY 1990 appropriation by $6.5 million (or 8 percent). EPA recommends re-allocating the money to higher priority initiatives.

Hardest hit would be engineering and technology-related R&D, which is slated for a 21 percent cut. Funding for the Gulf Coast Research Center would end. The Superfund innovative technology program would maintain its current pace of doing 10 field demonstrations of technologies for separating, stabilizing, detoxifying, and destroying these substances. In total, however, less would be spent on technologies to clean up or treat sites.

Some of the remaining resources would be concentrated on biological systems for degrading hazardous materials. EPA plans to "significantly" increase research on the subsurface processes that affect soil and groundwater contamination and cleanup. To promote in situ bioremediation, EPA researchers hope to enhance the effectiveness of both indigenous and genetically designed microorganisms. Reports on the genetics and biochemistry of bacterial degradation of PCBs should be available in FY 1991.

Another goal is to improve remote and on-site monitoring technologies. Work on volatile organic compounds would be assigned high priority, as these pose the most common threat at Superfund sites. A new program would be started to evaluate the health and environmental risks posed by spills and cleanups.

Toxic Substances Research

EPA controls the use of toxic chemicals through a combination of preventive and regulatory measures. The $28.6 million requested for toxics research supports these efforts by strengthening government and industry assessments of the risks associated with these substances.

The proposed budget would boost toxics R&D by $1.9 million (or 7 percent), primarily for research on preventing lead pollution and reviewing biotechnology products. Most of the money added for lead prevention would support extramural engineering and assessment research.

R&D on biotechnology issues would cut across all disciplines. The agency wants to standardize procedures for monitoring routine releases of genetically engineered materials. In the health area, studies would compare the effects of bioengineered organisms with those caused by natural organisms. The agency also would examine their geographic dispersal. Technology R&D would focus on factors affecting biotechnology processing equipment.

Research would continue on methods for evaluating industry data, monitoring human exposure, simulating impacts on ecosystems, and predicting human health risks. At the urging of a special task force, EPA plans to pursue technologies for treating the toxic effects of dye-class compounds in wastewater systems. Additional funding has been requested for the operation of a materials containment facility.

EPA also needs to validate the toxic emissions data being submitted under the Emergency Planning and Community Right-to-Know Act (EPCRA). This requires ongoing scientific review of the methods used for analyzing and monitoring the data.

Finally, asbestos issues remain on the R&D agenda. In FY 1991, the agency would try to improve techniques for analyzing exposure to airborne and durable fibers, and for containing/removing small fibers.

Pesticides Research

EPA's pesticide control laws require ongoing scientific review of pesticide registration, marketing, and use. The agency has asked for an additional $2.8 million for FY 1991 for pesticide R&D, bringing the total up to $15.4 million.

Ecological research would tap about $2 million of the new money, primarily for studies on preventing pollution, biotechnology, and risk assessment. Work on receptor organisms would improve assessments of genetically altered biological control agents (BCAs) and altered microbial pest control agents (MPCAs). Models would be developed to predict the link between pesticides and marine organisms. EPA hopes to improve the quality and timeliness of risk assessments by standardizing certain testing methods and by restructuring its databases.

Funding also would be added to the health R&D budget to accommodate more research on biotechnology issues. The agency's modelling efforts would focus on extrapolating from animal toxicity studies, estimating dermal absorption of pesticides, identifying metabolic differences among species, and gauging microbial agents in mammalian cells.

Resources added for monitoring studies would be earmarked for R&D on pollution prevention and for a pesticide profile of the Chesapeake Bay. Studies would focus on preventing groundwater contamination and on using bioregulation instead of pesticides.

The agency has completed most research on technologies for destroying and disposing of indemnified pesticides.

Multi-Media Research

Integrated, or "multi-media" research soon could be the largest component of EPA's research budget. It is projected to grow from 11 percent of the agency's R&D total in FY 1989 to 25 percent by FY 1991. The $111.4 million requested for next year is $26.1 million (or 31 percent) more than the current appropriated level.

Over 70 percent of the multi-media budget would be used for long-term, "core" research on ecological, health, and risk assessment issues. Research grants and academic centers also fall in this category.

At $34.3 million, the request for grants and centers exceeds current levels by $12.3 million, or 56 percent. Over 95 percent of this money supports extramural research. The added funds would enable EPA to sponsor 150 new projects (up from 50 in 1989) and to continue 130 existing projects (up from 12 in 1989). Eight academic centers would continue research on national groundwater and hazardous waste issues. However, the location of the centers would change, because 1990 is the final year for seven of the centers, and 1991 is the last year for the eighth.

The budget proposes $26.7 million for developing indicators of the condition of various ecosystems (up $6 million, or 29 percent). EPA would start monitoring in the Gulf of Mexico, based on experience gained from a near-coastal demonstration project in the mid-Atlantic region. Likewise, forest monitoring underway in northeastern states would be extended to southeastern areas. New demonstration projects would be designed to produce indicators of the ecological condition of freshwater, estuarine, and marine agricultural systems.

Most of the "core" health research involves projects previously transferred from air research: the NHANES-III survey and TEAM human exposure assessment models. EPA wants to create a new Center for Environmental Epidemiology Research, and has asked for $1.5 million to establish it. The center would be charged with developing methods of assessing public health, potential problems, and risk reduction measures. Funding for the center helps boost the request for health research up to $14 million.

The multi-media program would house the agency's largest pollution prevention effort ($4.6 million in FY 1991). EPA would investigate products, industrial processes, and disposal methods that are both economically and "environmentally preferable." The agency also is interested new ways of managing such complex problems as climate change, pollution from non-point sources, and radon. Specifically, EPA would develop "information and communications" strategies, in the belief that the existing "command and control" approaches are unsuited to these new challenges.

EPA plans two new information and liaison activities to reinforce the R&D on pollution prevention. Information and technologies developed by the research would be passed on to municipalities and to small- and medium-sized industries. The agency also would assist universities in setting up pollution prevention centers. Funding for technical information programs would total $11.4 million in FY 1991.

Other interdisciplinary research would study lead exposure and abatement, uniform risk assessments, and quality assurance. The multi-media budget also includes funds for a variety of other institutional research arrangements, including the visiting scientists program, small business awards, joint studies with China on urban and rural health issues, and a task force on environmental cancer and heart and lung disease.

For capital investments, the budget requests $8.4 million (a $2.6 million increase). The money would be used to partially replace some aging equipment at research labs and to purchase new state of the art equipment.

Radiation Research

Radon tops the radiation R&D priorities. EPA hopes to spend $4.1 million on radiation studies in FY 1991, reflecting a proposed $0.4 million increase for radon mitigation, especially in schools.

EPA plans to use the $3.8 million budgeted for radon R&D to evaluate a variety of mitigation techniques for new and existing homes, and to demonstrate sub-slab suction systems in school systems. The agency also would determine whether techniques used to reduce radon in homes could be applied to schools. Approximately $0.3 million would be spent on EPA's monitoring of radiation exposure at various Energy Department locations.

Leaking Underground Storage Tank (LUST) Research

Funding for engineering studies on corrective and remedial actions taken at LUST sites would remain unchanged at $0.8 million. As in past years, tests would focus on in-situ soil flushing and soil washing techniques.

Agency Tables

Table II-1. R&D in the FY 1991 Budget by Agency in Current Dollars (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91	
				Current $	Constant $
Conduct of R&D					
Defense (military)	$38,031.2	$37,225.7	$38,714.1	4.0%	–0.2%
National Aeronautics and Space Administration	5,303.2	6,381.7	8,413.5	31.8%	26.5%
Energy	5,437.1	6,023.2	6,057.9	0.6%	-3.5%
Health and Human Services	7,894.5	8,505.6	8,933.4	5.0%	0.8%
(National Institutes of Health)	(6,775.8)	(7,140.0)	(7,470.1)	(4.6%)	(0.4%)
National Science Foundation	1,670.7	1,765.8	1,983.3	12.3%	7.8%
Agriculture	1,050.8	1,101.4	1,174.7	6.7%	2.4%
Interior	467.1	502.7	493.0	–1.9%	–5.9%
Transportation	313.4	335.6	421.5	25.6%	20.5%
Environmental Protection Agency	387.2	424.0	449.6	6.0%	1.8%
Commerce	417.2	424.7	442.5	4.2%	0.0%
Nuclear Regulatory Commission	114.8	109.3	116.2	6.3%	2.0%
Veterans Affairs	212.2	214.6	201.4	–6.2%	–9.9%
Agency for International Development	260.9	230.3	214.2	–7.0%	–10.7%
Labor	25.1	29.0	29.6	2.1%	–2.0%
Education	145.6	160.2	162.9	1.7%	–2.4%
Tennessee Valley Authority	56.5	56.0	52.4	–6.4%	–10.2%
Smithsonian	82.0	88.0	100.0	13.6%	9.1%
Housing and Urban Development	16.2	19.5	47.1	141.5%	131.8%
Corps of Engineers	37.4	34.8	48.7	39.9%	34.3%
Justice	37.1	37.0	35.9	–3.0%	–6.9%
Treasury	27.3	28.2	28.2	0.0%	–4.0%
TOTAL Conduct of R&D	$61,987.5	$63,697.3	$68,120.1	6.9%	2.6%

Table II-1. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91	
				Current $	Constant $
Facilities					
Department of Energy	$818.0	$1,139.2	$1,324.8	16.3%	11.6%
Defense (military)	547.0	639.1	457.7	-28.4%	-31.3%
National Aeronautics and Space Administration	616.3	850.1	846.3	-0.4%	-4.5%
Agriculture	88.2	114.5	82.4	-28.0%	-30.9%
Health and Human Services	69.2	77.2	96.4	24.9%	19.8%
(National Institutes of Health)	(46.1)	(76.5)	(90.2)	(17.9%)	(13.2%)
National Science Foundation	91.1	119.4	152.6	27.8%	22.7%
Transportation	12.9	24.7	17.8	-27.9%	-30.8%
Tennessee Valley Authority	0.6	0.2	0.1	-50.0%	-52.0%
Commerce	9.4	14.6	16.6	13.7%	9.1%
Veterans Affairs	5.8	5.6	4.8	-14.3%	-17.7%
Agency for International Development	10.4	9.2	7.0	-23.9%	-27.0%
Smithsonian	3.0	5.0	5.0	0.0%	-4.0%
Interior	12.5	18.8	5.5	-70.7%	-71.9%
Education	1.8	1.8	1.8	0.0%	-4.0%
Treasury	0.1	0.1	0.1	0.0%	-4.0%
Environmental Protection Agency	10.1	0.0	19.2	100.0%	100.0%
TOTAL, Facilities	$2,296.4	$3,019.5	$3,038.1	0.6%	-3.5%
TOTAL R&D	$64,283.9	$66,716.8	$71,158.2	6.7%	2.3%

Source: OMB's data for R&D analysis for FY 1991, and agency budget justifications. Conversion to constant dollars by authors based on OMB deflators.

Table II-2. R&D in the Department of Defense—FY 1991 Budget (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Research, Development, Test & Evaluation				
Research	$950.7	$923.5	$977.8	5.9%
Exploratory Development	2,555.4	2,403.1	2,457.5	2.3%
Technology Base	$3,506.0	$3,326.6	$3,435.4	3.3%
Advanced Technology Development	$5,836.6	$5,858.1	$6,316.6	7.8%
Strategic Programs	6,427.5	5,364.3	5,608.9	4.6%
Tactical Programs	12,989.1	13,446.1	13,480.5	0.3%
Intelligence and Communications Programs	4,512.4	4,779.0	4,957.4	3.7%
Defense-wide Mission Support	4,233.9	3,943.8	4,294.1	8.9%
TOTAL, RDT&E	$37,505.6	$36,717.9	$38,092.8	3.7%
Other Appropriations[1]	1,072.6	1,146.9	1,079.0	-5.9%
TOTAL, DOD R&D	$38,578.2	$37,864.8	$39,171.8	3.5%
TOTAL, Conduct of R&D	$38,031.2	$37,225.7	$38,714.1	4.0%
TOTAL, R&D Facilities	547.0	639.1	457.7	-28.4%

Source: Department of Defense "RDT&E Programs (R-1)," January 1990, and OMB's data for R&D analysis for FY 1991

[1] R&D support in military personnel, military construction, and other DOD appropriations.

Table II-3. DOD R&D by Military Department and Agencies (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Research, Development, Test & Evaluation				
Army	$5,154.2	$5,418.7	$6,025.9	11.2%
Navy	9,281.5	9,465.8	9,102.4	-3.8%
Air Force	14,668.2	13,496.9	13,276.3	-1.6%
Defense Agencies	8,181.9	8,145.5	9,249.3	13.6%
Defense Mapping Agency	302.7	265.5	232.1	-12.6%
Strategic Defense Initiative Organization	3,627.4	3,571.2	4,460.0	24.9%
Office, Secretary of Defense	1,076.3	1,032.5	1,054.7	2.2%
Defense Advanced Research Projects Agency	1,289.1	1,227.0	1,078.3	-12.1%
Defense Nuclear Agency	329.5	356.8	446.1	25.0%
Defense Support Project Office	137.4	123.2	225.7	83.1%
Joint Chiefs of Staff	0.0	0.0	84.6	100.0%
Defense Communications Agency	182.4	232.6	174.1	-25.2%
Defense Logistics Agency	61.3	53.4	42.7	-20.0%
Uniformed Services University of the Health Sciences	2.1	2.2	2.3	7.0%
Special Operations Command	0.0	0.0	207.2	100.0%
All Other[1]	1,173.8	1,281.0	1,241.5	-3.1%
Director of Test & Evaluation, Defense	149.1	178.2	348.1	95.3%
Director of Operational Test & Evaluation	70.7	12.7	90.8	613.6%
TOTAL, RDT&E	$37,505.6	$36,717.9	$38,092.8	3.7%
Other Appropriations[2]	1,072.6	1,146.9	1,079.0	-5.9%
TOTAL DOD R&D[3]	$38,578.2	$37,864.8	$39,171.8	3.5%

Source: Department of Defense "RDT&E Programs (R-1)," January 1990, and OMB's data for R&D analysis for FY 1991.

[1] Includes Defense Intelligence Agency, National Security Agency, and Joint Tactical C3 Agency

[2] R&D support in military personnel, military construction, and other DOD appropriations.

[3] Includes conduct of R&D and R&D facilities.

Table II-4. Department of Defense R&D by Character of Work, FY 1991 Budget (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Current Dollars				
Basic Research	$950.7	$923.5	$977.8	5.9%
Applied Research	2,540.8	2,403.1	2,457.5	2.3%
TOTAL, Research	$3,491.5	$3,326.6	$3,435.3	3.3%
Development[1]	34,539.7	33,899.1	35,278.8	4.1%
TOTAL, Conduct of R&D	$38,031.2	$37,225.7	$38,714.1	4.0%
R&D Facilities	547.0	639.1	457.7	–28.4%
TOTAL R&D	$38,578.2	$37,864.8	$39,171.8	3.5%
Constant FY 1982 Dollars				
Basic Research	$751.6	$702.0	$713.4	1.6%
Applied Research	2,008.7	1,826.8	1,792.9	–1.9%
TOTAL, Research	$2,760.3	$2,528.8	$2,506.2	0.9%
Development	27,306.3	25,769.0	25,737.8	0.1%
TOTAL, Conduct of R&D	$30,066.6	$28,297.8	$28,244.0	0.2%
R&D Facilities	432.4	485.8	333.9	–31.3%
TOTAL R&D	$30,499.0	$28,783.6	$28,578.0	0.7%

Source: OMB's data for R&D analysis for FY 1991. Conversion to constant dollars based on OMB fiscal year deflators for national defense R&D.

[1] Includes expenses of test and evaluation.

Table II-5. Department of Defense Funding for Basic Research (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Army				
Defense Research Sciences	$170.9	$172.6	$179.5	4.0%
In-House Independent Research	0.0	8.9	9.4	5.4%
University Research Initiative	0.0	0.0	0.0	
TOTAL, Army	$170.9	$181.6	$188.9	4.0%
Navy				
Defense Research Sciences	$329.0	$341.6	$374.4	9.6%
In-House Independent Research	23.4	24.3	26.8	10.1%
University Research Initiative	0.0	0.0	0.0	
TOTAL, Navy	$352.4	$365.9	$401.2	9.6%
Air Force				
Defense Research Sciences	$6.9	$7.5	$8.3	11.7%
In-House Independent Research	190.3	182.2	193.2	6.0%
University Research Initiative	0.0	0.0	0.0	
TOTAL, Air Force	$197.2	$189.6	$201.5	6.3%
Defense Agencies				
Defense Research Sciences	$88.6	$78.2	$85.2	9.1%
In-House Independent Research	2.1	2.2	2.3	7.0%
University Research Initiative	95.0	96.0	98.7	2.8%
HF Active Auroral	0.0	10.0	0.0	-100.0%
Unspecified	44.5	0.0	0.0	0.0%
TOTAL, Defense Agencies	$230.2	$186.3	$186.3	0.0%

Table II-5. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
TOTAL DOD				
Defense Research Sciences	$595.4	$599.8	$647.4	7.9%
In-House Independent Research	215.8	217.7	231.7	6.5%
University Research Initiative	95.0	96.0	98.7	2.8%
HF Active Auroral	0.0	10.0	0.0	–100.0%
Unspecified	44.5	0.0	0.0	0.0%
TOTAL, DOD Basic Research	$950.7	$923.5	$977.8	5.9%

Source: Department of Defense "RDT&E Programs (R-1)," January 1990, and OMB's data for R&D analysis for FY 1991.

Table II-6. Trends in Department of Defense R&D, FY 1965–1990 (in millions)

	Basic Research[1]		Total DOD R&D[2]	
Fiscal Years	Current $	Constant FY 1982 $	Current $	Constant FY 1982 $
1965	$347	$1,345	$6,865	$26,609
1970	323	944	7,491	21,891
1975	305	570	9,167	17,122
1980	552	676	14,150	17,336
1981	615	668	16,772	18,211
1982	697	697	20,866	20,866
1983	787	754	23,233	22,264
1984	843	784	26,940	25,056
1985	851	767	31,632	28,500
1986	954	840	35,000	30,807
1987	894	770	37,136	31,983
1988	897	742	38,126	31,569
1989	951	752	38,578	30,499
1990 Estimate	924	702	37,865	28,784
1991 Budget	978	713	39,172	28,578

Source: National Science Foundation historical reports and OMB's data for R&D analysis for FY 1991. Constant dollar conversions based on most recent OMB fiscal year deflators for national defense R&D.

[1] Budget authority for DOD "6.1" category.

[2] Conduct of R&D and R&D facilities.

Table II-7. R&D in the National Science Foundation (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Mathematical and Physical Sciences (MPS)				
Mathematical Sciences	$66.0	$69.1	$73.7	6.7%
Astronomical Sciences	89.2	91.6	100.7	9.9%
Physics	122.3	123.8	130.2	5.2%
Chemistry	96.7	97.9	103.4	5.5%
Materials Research	115.1	116.9	123.5	5.6%
Science and Technology Centers	13.9	14.5	27.0	86.0%
Major Research Equipment	0.5	43.0	63.0	46.5%
TOTAL, MPS	$503.8	$557.0	$621.5	11.6%
Engineering				
Chemical and Thermal Systems	$31.0	$34.2	$33.1	–3.0%
Mechanical and Structural Systems	23.0	25.3	24.4	–3.4%
Electrical and Communications	29.9	32.9	31.8	–3.4%
Design and Manufacturing Systems	18.1	20.7	19.8	–4.5%
Biological and Critical Systems	34.1	39.4	36.1	–8.4%
Engineering Centers	40.4	47.7	55.3	15.9%
Engineering Infrastructure Development	10.6	0.0	25.4	—
TOTAL, Engineering	$187.1	$200.2	$226.0	12.9%

Table II-7. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Biological, Behavioral and Social Sciences (BBS)				
Molecular Biosciences	$46.7	$48.0	$52.0	8.2%
Cellular Biosciences	55.5	57.3	63.1	10.0%
Biotic Systems and Resources	62.8	66.7	73.4	10.0%
Behavioral and Neural Sciences	44.8	45.8	49.1	7.0%
Social and Economic Sciences	30.9	32.3	35.5	10.0%
Instrumentation and Resources	36.6	38.5	43.2	12.4%
Science and Technology Centers	4.2	4.9	11.3	131.1%
TOTAL, BBS	$281.5	$293.5	$327.5	11.6%
Geosciences				
Atmospheric Sciences	$98.6	$104.1	$120.1	15.4%
Earth Sciences	54.2	60.1	71.5	19.0%
Ocean Sciences	145.9	147.4	171.0	16.0%
Arctic Research Program	10.3	12.5	16.7	33.7%
Science and Technology Centers	0.9	1.0	4.4	351.5%
TOTAL, Geosciences	$309.9	$325.0	$383.7	18.1%
Computer and Information Science and Engineering (CISE)				
Computer and Computation Research	$21.2	$22.0	$24.3	10.5%
Information, Robotics and Intelligent Systems	19.1	20.0	22.9	14.5%
Microelectronic Information Processing Systems	15.0	16.6	18.9	13.6%
Advanced Scientific Computing	55.6	62.8	62.6	-0.4%
Networking and Communications Research and Infrastructure	17.6	22.2	31.3	41.0%
Cross-Disciplinary Activities	17.4	19.6	24.0	22.4%
Science and Technology Centers	5.9	6.6	9.3	41.9%
TOTAL, CISE	$151.8	$169.8	$193.3	13.8%

Table II-7. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Scientific, Technological and International Affairs (STIA)				
Industrial Science and Technological Innovation	$19.1	$20.0	$22.9	14.4%
International Cooperative Scientific Activities	11.2	11.2	12.1	7.5%
Policy Research and Analysis	0.9	0.8	0.9	0.8%
Science Resources Studies	4.3	5.3	6.0	12.7%
Research Initiation and Improvement	22.9	26.0	32.2	23.5%
TOTAL, STIA	$58.3	$63.5	$74.0	16.6%
Research Facilities Modernization	$0.0	$19.7	$20.0	1.6%
Program Management	91.3	96.4	102.5	6.3%
Headquarters Relocation	0.0	0.0	5.5	—
Carryover from FY 1989	0.0	38.0	0.0	-100.0%
TOTAL, Research and Related Activities	$1,583.7	$1,763.1	$1,954.0	10.8%
U.S. Antarctic Program	$131.1	$151.9	$175.0	15.2%
Science and Engineering Education				
Teacher Preparation and Enhancement	$63.7	$81.0	$89.6	10.6%
Materials Development and Informal Science Education	44.0	48.0	61.5	28.1%
Undergraduate Science, Engineering and Mathematics Education	28.0	34.0	50.0	47.1%
Research Career Development	31.0	36.9	44.9	21.7%
Studies and Program Assessment	4.5	4.4	5.0	14.5%
Carryover from FY 1989	0.0	0.1	0.0	-100.0%
TOTAL, Science and Engineering Education	$171.1	$204.3	$251.0	22.8%

Table II-7. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Inspector General	$0.0	$2.6	$3.0	17.2%
BA Adjustment	37.8	–37.4	0.0	
TOTAL, NSF Budget	$1,923.7	$2,084.4	$2,383.0	14.3%
Deduct Science Education other than R&D, and other Non-R&D	–161.9	–199.2	–247.1	24.1%
TOTAL, NSF R&D	$1,761.8	$1,885.2	$2,135.9	13.3%

Source: Agency budget justification and OMB's data for R&D analysis for FY 1991.

Table II-8. R&D in the Department of Health and Human Services (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Conduct of R&D				
Health				
National Institutes of Health	$6,775.8	$7,140.0	$7,470.1	4.6%
Alcohol, Drug Abuse, and Mental Health Administration	728.5	897.3	988.5	10.2%
Centers for Disease Control	117.8	125.9	130.8	3.9%
Food and Drug Administration	99.0	110.0	125.5	14.1%
Assistant Secretary for Health[1]	27.1	57.1	47.3	−17.2%
Health Care Financing Administration	9.7	12.9	13.0	0.8%
Health Resources and Services Administration	10.0	10.1	10.1	0.0%
Indian Health	0.6	0.7	0.7	0.0%
TOTAL, Health	$7,768.5	$8,354.0	$8,786.0	5.2%
Human Services				
Office of Human Development Services	$99.4	$117.0	$121.5	3.8%
Social Security Administration	15.9	19.8	16.6	−16.2%
Departmental Management	7.9	5.0	5.0	0.0%
Family Support Administration	2.8	9.8	4.3	−56.1%
TOTAL, Human Services	$126.0	$151.6	$147.4	−2.8%
TOTAL, Conduct of R&D	$7,894.5	$8,505.6	$8,933.4	5.0%

Table II-8. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
R&D Facilities				
National Institutes of Health	$46.1	$76.5	$90.2	17.9%
Alcohol, Drug Abuse and Mental Health Administration	0.1	0.2	3.1	1,450.0%
Food and Drug Administration	23.0	0.5	3.0	500.0%
Indian Health Services	0.0	0.1	0.1	0.0%
TOTAL, R&D Facilities	$69.2	$77.3	$96.4	24.7%
TOTAL, HHS R&D	$7,963.7	$8,582.9	$9,029.8	5.2%

Source: OMB's data for R&D analysis for FY 1991, and budget justifications for NIH and ADAMHA.

[1] Includes funding for Public Health Services Management.

Table II-9. R&D in the National Institutes of Health by Institute (budget authority in millions)[1]

Institute	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Cancer	$1,539.7	$1,598.5	$1,658.3	3.7%
Heart, Lung, and Blood	1,006.4	1,027.9	1,068.0	3.9%
Dental Research	125.7	129.9	134.6	3.7%
Diabetes, Digestive, and Kidney Diseases	537.9	557.6	581.5	4.3%
Neurological Disorders and Stroke	459.6	477.4	499.2	4.6%
Allergy and Infectious Diseases	729.4	815.5	869.4	6.6%
General Medical Sciences	608.6	629.2	659.8	4.9%
Child Health and Human Development	412.0	426.4	444.9	4.4%
Eye	225.3	229.4	240.3	4.7%
Environmental Health Sciences	214.6	218.6	225.2	3.0%
Aging	214.3	229.9	239.4	4.1%
Arthritis and Musculoskeletal & Skin Diseases	153.7	162.2	169.3	4.4%
Deafness and Communications Disorders	92.2	114.5	119.7	4.6%
Research Resources	338.4	334.6	316.7	–5.4%
Nursing Research	25.7	29.3	30.9	5.5%
Human Genome	28.2	56.6	103.0	82.0%
Fogarty International Center	14.2	15.7	16.4	4.5%
National Library of Medicine	77.9	85.7	89.9	4.9%
Office of Director	46.7	89.9	83.0	–7.7%
Adjustments	–74.9	–88.6	–79.4	–10.5%
TOTAL, Conduct of R&D	$6,775.8	$7,140.0	$7,470.1	4.6%

Source: Agency FY 1991 budget justification.

[1] Excludes training and buildings and facilities.

Table II-10. R&D in the National Institutes of Health by Funding Mechanism (budget authority in millions)[1]

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Research Grants:				
Research Projects	$4,033.7	$4,197.9	$4,424.8	5.4%
Noncompeting	(3,028.8)	(3,231.8)	(3,345.2)	(3.5%)
Administrative Supplementals	(22.4)	(22.8)	(21.1)	(-7.3%)
Competing	(982.5)	(943.3)	(1,058.5)	(12.2%)
Research Centers	605.1	634.9	669.6	5.5%
Other Research Grants	371.0	378.7	357.7	-5.6%
R&D Contracts	543.2	576.5	592.9	2.8%
Intramural Research	788.8	855.9	914.9	6.9%
Research Management and Support	302.8	317.7	339.7	6.9%
Disease Control	74.1	74.9	75.5	0.7%
Other	57.1	103.3	95.0	-8.0%
TOTAL, Conduct of R&D	$6,775.8	$7,140.0	$7,470.1	4.6%

Source: Agency FY 1991 budget justification.

[1] Excludes training and buildings and facilities.

Table II-11. Research in the Alcohol, Drug Abuse, and Mental Health Administration (budget authority in millions)[1]

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change FY 1990-91
General Mental Health	$371.4	$429.7	$456.1	6.2%
Drug Abuse	188.2	247.7	292.2	18.0%
Alcoholism	116.7	142.7	149.8	5.0%
Undistributed R&D[2]	52.3	77.5	93.5	20.6%
TOTAL ADAMHA R&D	$728.6	$897.5	$991.6	10.5%

Source: Agency FY 1991 budget justification.

[1] Excludes training, community programs, and "buildings and facilities."

[2] At the time this report went to press, ADAMHA had not allocated these amounts among the institutes. Most of this money is derived from the budgets for demonstrations.

Table II-12. R&D in the Department of Energy (budget authority in millions; includes plant and capital equipment)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
DOE Appropriations Containing R&D				
1. Energy Supply R&D	$1,585.5	$1,682.7	$1,851.0	10.0%
2. Fossil Energy R&D	312.7	344.7	167.1	-51.5%
3. Energy Conservation	143.6	174.9	163.6	-6.5%
4. General Science and Research	905.2	1,089.5	1,264.1	16.0%
5. Atomic Energy Defense Activities	2,957.0	3,023.3	3,145.4	4.0%
6. Uranium Enrichment	125.5	132.3	154.5	16.8%
7. Clean Coal Technology	173.8	531.5	431.0	-18.9%
8. Environmental Restoration	51.8	183.5	206.0	12.3%
TOTAL DOE R&D	$6,255.1	$7,162.4	$7,382.7	3.1%
1. Energy Supply R&D				
Solar				
Solar Building Energy Systems	$2.3	$1.3	$1.0	-20.6%
Photovoltaic Energy Systems	35.1	34.7	43.6	25.8%
Solar Thermal Energy Systems	14.8	15.0	19.5	29.9%
Biofuels Energy Systems	13.8	16.3	28.0	71.9%
Wind Energy Systems	8.8	9.1	8.6	-5.8%
Ocean Energy Systems	4.1	4.1	0.0	-100.0%
International Solar Energy Program	1.0	1.0	1.5	45.9%
Solar Technology Transfer	2.4	1.8	2.2	25.0%
Solar Energy Research Institute (SERI)	0.6	0.6	5.2	702.5%
Program Support and Resource Assessment	1.7	1.6	1.9	16.4%
TOTAL, Solar	$84.8	$85.1	$111.5	31.0%
Geothermal	$18.7	$17.3	$17.1	-1.2%
Hydropower	0.0	0.0	1.0	—

Table II-12. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Nuclear Energy				
Light Water Reactors	26.5	24.4	31.5	29.0%
Advanced Reactor R&D	74.0	58.8	47.0	-20.0%
Advanced Radioisotope Power Systems[1]	36.0	49.0	75.5	53.9%
Space/Reactor Power Systems[2]	63.0	31.3	54.5	74.1%
Facilities	139.6	169.6	140.5	-17.2%
TOTAL, Nuclear Energy	$339.0	$333.1	$349.0	4.8%
Remedial Action and Waste Technology	0.6	0.0	0.0	0.0%
TOTAL, Nuclear Energy R&D	$339.6	$333.1	$349.0	4.8%
Magnetic Fusion	$340.1	$315.3	$319.6	1.4%
Electric Energy Systems and Energy Storage Systems	35.6	29.7	39.2	32.0%
Biological and Environmental Research	246.8	304.2	333.0	9.5%
Basic Energy Sciences				
Materials Sciences	173.7	198.7	222.0	11.7%
Chemical Sciences	127.8	140.3	150.5	7.3%
Applied Mathematical Sciences	42.1	43.7	48.0	9.8%
Engineering and Geosciences	32.8	33.2	32.5	-2.1%
Advanced Energy Projects	14.4	14.6	24.0	64.5%
Energy Biosciences	20.4	20.6	20.2	-2.2%
Capital Equipment and Construction	78.7	113.3	145.1	28.0%
TOTAL, Basic Energy Sciences	$489.8	$564.4	$642.2	13.8%
Energy Research Analyses	$3.8	$3.8	$3.7	-2.6%
University Research Support	21.4	24.9	29.8	19.7%
University Research Instrumentation	4.9	4.9	4.9	0.0%
TOTAL, Energy Supply R&D	$1,585.5	$1,682.7	$1,851.0	10.0%

Table II-12. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
2. Fossil Energy R&D				
Coal	$242.3	$275.3	$110.3	-59.9%
Petroleum	38.3	39.9	40.7	2.0%
Gas	11.4	14.4	13.7	-5.2%
Cooperative R&D	0.0	4.6	0.0	-100.0%
Facilities	21.8	12.0	2.4	-80.1%
Less Use of Prior Year Balances	-1.0	-1.6	0.0	—
TOTAL, Fossil Energy R&D	$312.7	$344.7	$167.1	-51.5%
3. Energy Conservation				
Buildings and Community Systems	$32.2	$35.3	$42.3	19.7%
Industrial Energy Conservation	28.2	48.7	38.0	-21.9%
Transportation Energy Conservation	52.1	62.7	54.3	-13.4%
Multisector	31.1	34.8	31.3	-10.2%
Facilities	13.0	0.0	4.0	—
Policy and Management	1.8	3.5	3.5	0.1%
Non-R&D Program Support	-14.7	-10.1	-9.7	-3.2%
TOTAL, Energy Conservation R&D	$143.6	$174.9	$163.6	-6.5%
4. General Science and Research				
High Energy Physics	$549.8	$582.1	$621.2	6.7%
Nuclear Physics	257.9	289.7	330.7	14.2%
Superconducting Super Collider	98.1	218.6	317.9	45.4%
BA Adjustment	-0.6	-0.8	-5.7	—
TOTAL, General Science and Research	$905.2	$1,089.5	$1,264.1	16.0%

Table II-12. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
5. Atomic Energy Defense Activities				
Naval Reactors Development	$617.0	$628.9	$638.0	1.4%
Weapons R&D and Testing	1,839.5	1,863.8	1,884.6	1.1%
Verification and Control Technology	59.5	57.2	50.5	–11.7%
Nuclear Safeguards and Security	36.2	34.3	34.9	1.7%
Production Reactor	183.1	206.3	311.2	50.8%
Materials Production	221.7	232.8	226.2	–2.8%
TOTAL, Atomic Energy Defense Activities	$2,957.0	$3,023.3	$3,145.4	4.0%
6. Uranium Enrichment	$125.5	$132.3	$154.5	16.8%
7. Clean Coal Technology	$173.8	$531.5	$431.0	–18.9%
8. Environmental Restoration	$51.8	$183.5	$206.0	12.3%
TOTAL DOE R&D	$6,255.1	$7,162.4	$7,382.7	3.1%

Source: Agency FY 1991 budget justification.

[1] Formerly entitled "Advanced Nuclear Systems."

[2] Formerly entitled "Space and Defense Power Systems."

Table II-13. Department of Energy Funding to Multiprogram National Laboratories by Program Type (obligations in millions)

	Energy Supply R&D	Atomic Energy Defense Activities	General Science & Research	Fossil Energy R&D	Energy Conser-vation	Other*	Total
Ames Lab.	$20.3	$0.4	$1.7	$0.0	$0.0	$0.0	$22.5
(Change from FY 90)	(2.2)	(0.0)	(0.1)	(0.0)	(0.0)	(0.0)	(2.2)
Argonne Nat. Lab.	192.6	3.7	28.9	3.4	5.4	28.9	262.9
(Change from FY 90)	(34.5)	(–0.4)	(–2.2)	(–2.4)	(–1.4)	(4.6)	(32.8)
Brookhaven Nat. Lab.	113.8	2.2	125.2	0.7	0.4	18.8	261.1
(Change from FY 90)	(14.2)	(0.1)	(16.7)	(–0.2)	(–0.5)	(11.3)	(41.6)
Idaho Nat. Lab.	25.9	4.5	0.4	2.4	7.8	101.2	142.2
(Change from FY 90)	(–8.0)	(–0.1)	(0.0)	(0.9)	(–0.8)	(–10.3)	(18.3)
Lawrence Berkeley Lab.	100.9	0.0	60.1	0.9	8.4	18.2	188.6
(Change from FY 90)	(4.5)	(0.0)	(2.8)	(–0.4)	(–3.3)	(4.8)	(8.4)
Lawrence Livermore Lab.	84.6	527.8	2.4	0.6	0.3	169.7	785.4
(Change from FY 90)	(9.9)	(–26.2)	(–3.8)	(–4.1)	(–0.2)	(23.0)	(1.3)
Los Alamos Scientific Lab.	84.0	537.2	55.6	0.4	2.2	23.3	702.7
(Change from FY 90)	(9.9)	(–12.3)	(0.1)	(–0.5)	(–0.9)	(1.4)	(2.3)
Oak Ridge Nat. Lab.	199.0	6.8	15.7	4.7	25.1	32.8	284.2
(Change from FY 90)	(21.0)	(3.3)	(0.1)	(–0.8)	(1.3)	(–3.3)	(21.5)
Pacific Northwest Lab.	52.5	8.1	0.1	0.4	8.4	16.4	85.9
(Change from FY 90)	(1.0)	(–0.4)	(0.0)	(–0.6)	(3.1)	(2.1)	(5.3)
Sandia Labs.	61.9	771.4	0.0	4.3	7.4	32.4	877.5
(Change from FY 90)	(4.9)	(41.1)	(–0.2)	(–0.8)	(4.1)	(–4.4)	(44.7)
Savannah River Lab.	0.7	2.4	0.0	0.0	0.0	62.4	65.5
(Change from FY 90)	(0.2)	(0.5)	(0.0)	(0.0)	(0.0)	(–4.7)	(4.1)
Westinghouse Hanford Co.	74.4	3.0	0.0	0.1	0.0	0.5	78.0
(Change from FY 90)	(–32.5)	(0.5)	(0.0)	(0.0)	(0.0)	(–8.1)	(40.0)
TOTAL	$1,010.6	$1,867.5	$290.2	$17.9	$65.4	$504.7	$3,756.2
(Change from FY 90)	($61.7)	($6.0)	($13.7)	($8.8)	($1.5)	($16.2)	($90.4)

Source: Department of Energy, Office of Energy Research. (See Table II-12 for breakdown of program types.)

*"Other" includes: Nuclear Waste Fund, Departmental Administration, Clean Coal Technology, Economic Regulation (Argonne only), the Strategic Petroleum Reserve (Sandia only), Isotope Production and Distribution Fund (Oak Ridge only), and Uranium Enrichment (Lawrence Livermore only).

Table II-14. R&D in the National Aeronautics and Space Administration (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Research and Development Appropriation				
Space Station	$900.0	$1,749.6	$2,451.0	40.1%
Space Transportation Capability Development	674.0	562.4	773.4	37.5%
Space Science and Applications	1,824.2	2,003.8	2,481.6	23.8%
Physics and Astronomy	737.4	861.4	985.0	14.4%
Life Sciences	79.1	106.3	163.0	53.4%
Planetary Exploration	416.6	391.7	485.2	23.9%
Earth Science and Applications	403.4	439.3	661.5	50.6%
Materials Processing	75.6	99.0	97.3	−1.7%
Communications	92.2	78.0	52.8	−32.3%
Information Systems	19.9	28.2	36.8	30.5%
Commercial Programs	44.7	56.5	101.0	78.7%
Technology Utilization	16.5	23.7	24.4	3.0%
Commercial Use of Space	28.2	32.8	76.6	133.3%
Aeronautics Research and Technology	398.2	449.8	512.0	13.8%
Transatmospheric Research and Technology	69.4	59.0	119.0	101.6%
Space Research and Technology	285.9	285.9	532.9	86.4%
Safety, Reliability, and Quality Assurance	22.4	22.6	33.0	45.8%
Space Tracking and Data Systems	18.8	19.3	20.0	3.4%
Academic Programs[1]	(23.6)	37.0	50.1	35.3%
BA Adjustment	−25.0	0.0	0.0	0.0%
TOTAL, R&D Appropriation	$4,212.6	$5,246.0	$7,074.0	34.8%
TOTAL, R&D in Other Appropriations	1,706.9	1,985.8	2,185.8	10.1%
TOTAL NASA R&D	$5,919.5	$7,231.8	$9259.8	28.0%

Table II-14. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
TOTAL NASA R&D	$5,919.5	$7,231.8	$9,259.8	28.0%
(Conduct of R&D)	(5,303.2)	(6,381.7)	(8,413.5)	31.8%
(R&D Facilities)	(616.3)	(850.1)	(846.3)	–0.4%
TOTAL, NASA Operations[2]	$4,953.0	$4,990.0	$5,865.4	17.5%
TOTAL NASA Budget Authority	$10,872.5	$12,221.8	$15,125.2	23.8%
Detail of Research and Development Appropriation[3]				
Space Station				
System Development	$842.0	$1,661.2	$2,299.8	38.4%
Flight Telerobotic System	46.0	79.4	106.3	33.9%
Advanced Programs	12.0	9.0	36.0	300.0%
Operations	0.0	0.0	8.9	—
TOTAL, Space Station	$900.0	$1,749.6	$2,451.0	40.1%
Space Transportation: Capability Development				
Spacelab	$87.6	$95.6	$130.7	36.7%
Shuttle Upper Stages	131.6	84.6	91.3	7.9%
Engineering and Technology Base	160.6	181.6	218.5	20.3%
Payload Operations and Support Equipment	60.7	66.7	122.5	83.7%
Advanced Programs	52.7	33.6	53.2	58.3%
Tethered Satellite System	26.4	24.0	17.9	–25.4%
Orbital Maneuvering Vehicle	73.0	76.3	85.4	12.0%
Advanced Transportation Technology	81.4	(10.5)	53.9	413.3%
TOTAL, Space Transportation: Capability Development	$674.0	$562.4	$773.4	37.5%

Table II-14. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Physics and Astronomy				
Space Telescope Development	$104.9	$81.8	$0.0	-100.0%
Gamma Ray Observation Development	50.9	35.1	0.0	-100.0%
Advanced X-Ray Astrophysics Facilities	16.0	44.0	113.0	156.8%
Global Geospace Science	64.4	67.2	98.5	46.6%
Space Lab/Space Station Payload Development and Mission Management	67.7	81.2	89.1	9.7%
Space Station Integrated Planning	8.0	5.0	15.0	201.5%
Payload and Instrument Development	70.5	90.7	97.2	7.2%
Explorer Development	82.1	91.8	100.8	9.8%
Mission Operations and Data Analysis	142.4	202.4	293.9	45.2%
Research and Analysis	85.1	109.5	122.5	11.9%
Suborbital Program	45.4	52.7	55.0	4.4%
TOTAL, Physics and Astronomy	$737.4	$861.4	$985.0	14.4%
Planetary Exploration				
Galileo (Jupiter) Development	$73.4	$17.1	$0.0	-100.0%
Magellan (Venus) Development	43.1	0.0	0.0	0.0%
Ulysses International Solar Polar Mission	10.3	14.3	3.3	-76.8%
Mars Observer	102.2	98.9	68.9	-30.3%
Comet Rendezvous/Asteroid Flyby	0.0	29.5	148.0	401.4%
Mars Balloon Relay Experiment	0.0	4.4	2.0	-54.5%
Mission Operations and Data Analysis	110.7	156.9	173.5	10.6%
Research and Analysis	76.9	70.6	89.5	26.8%
TOTAL, Planetary Exploration	$416.6	$391.7	$485.2	23.9%

Table II-14. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Life Sciences				
Human Space Flight and Systems Engineering	$28.6	$40.7	$71.0	74.5%
Space Biological Systems	10.1	21.2	32.0	50.9%
Research and Analysis	40.4	44.4	60.0	35.1%
TOTAL, Life Sciences	$79.1	$106.3	$163.0	53.4%
Earth Science and Applications				
Payload Instrument Development	$46.4	$76.1	$49.7	-34.7%
Upper Atmosphere Res. Satellite	85.2	64.2	66.0	2.8%
Ocean Topography Experiment	83.0	80.8	68.0	-15.8%
Mission Operations and Data Analysis	17.6	23.9	30.4	27.2%
Airborne Science and Applications	23.0	19.4	20.2	4.1%
Scatterometer	10.6	13.6	3.7	-72.8%
Earth Observing System	0.0	0.0	103.0	—
Polar Platform	[20.4]	[74.0]	132.0	78.4%
Earth Probes	0.0	0.0	25.0	—
Process Studies	93.7	106.2	111.1	4.6%
Modelling and Data Analysis	34.1	38.5	41.3	7.3%
Laser Research Facilities	7.6	8.0	8.7	8.7%
Interdisciplinary Research	2.2	8.6	2.4	-72.1%
TOTAL, Earth Science and Applications	$403.4	$439.3	$661.5	50.6%
Other Space Applications				
Materials Processing in Space	$75.6	$99.0	$97.3	-1.7%
Advanced Communications Technology Systems	74.6	60.0	34.0	-43.3%
Advanced Communications Research	11.9	12.3	12.5	1.8%
Other Communications	5.7	5.7	6.3	10.0%
Information Systems R&D	19.9	28.2	36.8	30.5%
TOTAL, Other Space Applications	$187.7	$205.2	$186.9	-8.9%

Table II-14. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Commercial Programs				
Technology Utilization	$16.5	$23.7	$24.4	3.0%
Commercial Use of Space	28.2	32.8	76.6	133.3%
TOTAL, Commercial Programs	$44.7	$56.5	$101.0	78.7%
Aeronautics Technology				
Resource and Technology Base	$309.6	$326.1	$353.4	8.4%
Systems Technology Programs	88.6	123.6	158.6	28.3%
TOTAL, Aeronautics Technology	$398.2	$449.8	$512.0	13.8%
Space Research and Technology				
Resource and Technology Base	$124.1	$125.0	$125.7	0.6%
In-Space Experiments Technology Program	0.0	10.2	19.8	94.1%
CSTI	121.8	123.8	171.0	38.1%
Exploration Technology	40.0	26.9	179.4	566.9%
Exploration Mission Studies	(15.0)	(15.0)	37.0	146.7%
TOTAL, Space Research and Technology	$285.9	$285.9	$532.9	86.4%
Transatmospheric R&T/Space Plane	$69.4	$59.0	$119.0	101.6%
Safety, Reliability and Quality Assurance	22.4	22.6	33.0	45.8%
Space Tracking and Data Systems	18.8	19.3	20.0	3.4%
Academic Programs[1]	(23.6)	37.0	50.1	35.3%

Source: OMB's data for R&D analysis for FY 1991.

[1] Previously distributed throughout the agency.

[2] Includes Space Flight, Control and Data Communications funding and the non-R&D portion of the "Research and Program Management" account.

[3] R&D funding in the RPM and "Construction of Facilities" accounts.

Table II-15. R&D in the Department of Agriculture (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Conduct of R&D				
Agricultural Research Service	$525.3	$546.9	$587.8	7.5%
Cooperative State Research Service	307.9	324.9	335.4	3.2%
Competitive Research Grants	39.7	42.5	100.0	135.2%
Agricultural Experiment Stations	155.5	155.1	158.5	2.2%
Cooperative Forestry Research	17.5	17.3	13.0	-24.9%
1890 Colleges and Tuskegee	24.3	27.7	31.5	13.7%
Special Research Grants	45.6	56.3	25.6	-54.5%
Animal Health and Disease Research	5.5	5.4	0.0	-100.0%
Administration	6.4	7.9	1.2	-84.8%
Aquaculture	3.7	3.7	0.0	-100.0%
Alternative Crops Research	1.0	0.3	0.9	200.0%
International Trade Development	3.2	3.1	0.0	-100.0%
Agriculture Productivity	4.5	4.4	4.5	2.3%
Critical Materials	1.0	1.3	0.0	-100.0%
Forest Service	138.3	148.0	160.0	8.1%
Economics Research Service	49.3	50.7	56.3	11.0%
Agricultural Cooperative Service	2.7	2.8	2.9	3.6%
Agricultural Marketing Service	1.6	1.6	1.7	6.2%
Office of International Cooperation and Development	1.3	0.4	0.5	25.0%
Office of Transportation	1.0	1.0	1.0	0.0%
Human Nutrition Information Service	8.8	9.1	12.3	35.2%
National Agriculture Statistics Service	2.9	3.2	3.3	3.1%
Animal and Plant Inspection Service	11.3	12.5	13.2	5.6%
Federal Grain Inspection Service	0.4	0.3	0.3	0.0%
TOTAL, Conduct of R&D	$1,050.8	$1,101.4	$1,174.7	6.7%

Table II-15. (continued)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Facilities				
Agricultural Research Service	$61.1	$54.7	$73.3	34.0%
Cooperative State Research Service	25.5	49.3	0.0	-100.0%
Forest Service	1.6	4.5	5.1	13.3%
Animal and Plant Inspection Service	0.0	6.0	4.0	-33.3%
TOTAL, Facilities	$88.2	$114.5	$82.4	-28.0%
TOTAL, USDA R&D	$1,139.0	$1,215.9	$1,257.1	3.4%

Source: OMB's data for R&D analysis for FY 1991 and agency budget justification.

Table II-16. R&D in the Environmental Protection Agency by Media (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Air	$67.7	$77.8	$94.9	22.0%
Water Quality	24.1	26.7	28.9	8.1%
Drinking Water	21.3	21.8	22.8	4.9%
Hazardous Waste	43.5	43.7	41.2	-5.9%
Pesticides	13.3	12.6	15.4	22.2%
Radiation	3.5	3.7	4.1	11.8%
Multimedia[1]	43.5	85.3	111.4	30.5%
Toxic Substances	28.0	26.7	28.6	7.0%
Energy	54.5	32.2	14.3	-55.7%
Superfund	73.4	78.3	71.8	-8.3%
Leaking Underground Storage Tanks	0.8	0.8	0.8	1.8%
Management and Support	13.7	14.4	15.5	7.1%
Buildings and Facilities	10.1	0.0	19.2	—
TOTAL EPA R&D	$397.3	$424.0	$468.8	10.6%

Source: Agency FY 1991 budget justification.

[1] Formerly "Interdisciplinary"

Table II-17. R&D in the Environmental Protection Agency by Program (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change FY 1990-91
Health Effects	$48.1	$47.6	$49.6	$4.3%
Environmental Processes and Effects	47.3	50.5	55.7	10.2%
Monitoring Systems	52.3	51.8	54.0	4.2%
Acid Deposition	51.0	28.7	10.6	-63.2%
Scientific Assessment	18.6	21.5	21.4	-0.3%
Technical Information and Liaison	10.6	11.9	13.4	12.2%
Great Lakes Study	1.9	1.9	2.0	2.2%
Stratospheric Modification	9.6	15.4	26.0	68.8%
Environmental Engineering and Technology	76.6	88.7	82.6	-6.9%
Exploratory Research Program	14.7	8.7	9.4	8.7%
Characterization, Transport, and Fate	11.0	11.5	13.0	13.2%
Integrated Hazardous Waste Research	2.5	2.4	0.0	-100.0%
Core Research	24.8	57.5	79.5	38.3%
Multi-Media	3.2	2.9	3.1	6.2%
Oil Spills	0.0	1.0	2.0	105.3%
Quality Assurance	1.7	1.7	2.8	63.5%
Program Management and Support	14.0	15.0	16.2	8.1%
Capital Investment	0.0	5.9	8.5	43.3%
Facilities	10.1	0.0	19.2	—
TOTAL EPA R&D	$397.9	$424.6	$468.8	10.4%

Source: Agency FY 1991 budget justification.

Table II-18. R&D in the Department of the Interior (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Conduct of R&D				
Geological Survey	$279.9	$300.3	$305.1	1.6%
Bureau of Mines	96.1	100.4	77.7	–22.6%
Fish and Wildlife Service	62.0	72.0	69.1	–4.0%
National Park Service	19.2	19.5	22.8	16.9%
Bureau of Reclamation	3.6	4.4	8.8	100.0%
Bureau of Land Management	3.0	2.9	5.4	86.2%
Office of Surface Mining Reclamation and Enforcement	0.7	0.7	0.7	0.0%
Minerals Management Service	2.2	2.0	2.7	35.0%
Office of the Secretary	0.4	0.5	0.7	40.0%
TOTAL, Conduct of R&D	$467.1	$502.7	$493.0	–1.9%
R&D Facilities				
Geological Survey	$1.3	1.3	1.8	38.5%
Bureau of Mines[1]	2.3	0.0	0.0	0.0%
Fish and Wildlife Service[1]	6.7	2.1	1.9	–9.5%
BA Adjustment	2.2	15.4	1.8	
TOTAL, R&D Facilities[1]	$12.5	$18.8	$5.5	–70.7%
TOTAL, Interior R&D	$479.6	$521.5	$498.5	–4.4%

Source: OMB's data for R&D analysis for FY 1991.

[1] Budget for this account based on program level, due to BA adjustment.

Table II-19. R&D in the Department of Transportation (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Conduct of R&D				
Federal Aviation Administration[1]	$146.8	$215.2	$205.3	–4.6%
Federal Highway Administration[1]	90.3	83.8	118.6	41.5%
National Highway Traffic Safety Administration	29.7	27.7	48.0	73.3%
Coast Guard[1]	17.9	21.0	23.0	9.5%
Federal Railway Administration[1]	9.0	12.5	15.5	24.0%
Office of the Secretary[1]	5.5	7.1	7.2	1.4%
Research and Special Programs Administration	2.0	2.6	2.3	-11.5%
Urban Mass Transit Administration[1]	1.4	1.6	1.6	0.0%
Maritime Administration[1]	0.0	0.0	0.0	0.0%
BA Adjustment	10.8	–35.9	0.0	—
TOTAL, Conduct of R&D[1]	$313.4	$335.6	$421.5	25.6%
R&D Facilities				
Federal Aviation Administration[1]	$15.5	$18.6	$20.8	11.8%
Federal Railroad Administration	0	0.8	1.5	87.5%
BA Adjustment	–2.6	5.3	–4.5	
TOTAL, R&D Facilities[1]	$12.9	$24.7	$17.8	-27.9%
TOTAL DOT R&D	$326.3	$360.3	$439.3	21.9%

Source: OMB's data for R&D analysis for FY 1991.

[1] Budget estimates for this account based on program level, due to BA adjustment.

Table II-20. R&D in the Department of Commerce (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Conduct of R&D				
National Oceanic and Atmospheric Administration	$282.3	$284.7	$284.1	0.2
National Institute of Standards and Technology[1]	115.5	133.0	145.1	9.1%
National Telecommunications and Information Administration	7.7	8.0	8.3	3.8%
Bureau of the Census	5.0	5.0	5.0	0.0%
Economic Development Administration[1]	1.0	1.2	0.0	−100.00
BA Adjustment	5.7	−7.2	0	—
TOTAL, Conduct of R&D[1]	$417.2	$424.7	$442.5	4.2%
R&D Facilities				
National Oceanic and Atmospheric Administration	$0.5	$5.8	$3.6	−37.9%
National Institute of Standards and Technology[1]	8.6	10.1	13.0	28.7%
BA Adjustment	0.3	−1.3	0.0	—
TOTAL, R&D Facilities[1]	$9.4	$14.6	$16.6	13.7%
TOTAL Commerce R&D	$426.6	$439.3	$459.1	4.5%

Source: OMB's data for R&D analysis for FY 1991, and departmental data.

[1] Budget for this account is based on program level, due to BA adjustment.

Table II-21. R&D in the Department of Education (budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget	Percent Change, FY 1990-91
Conduct of R&D				
Rehabilitation Services and Handicapped Research	$54.5	$58.1	$56.6	-2.6%
Education Research and Statistics	27.7	32.7	39.1	19.6%
Handicapped Special Purpose Funds	26.9	27.9	27.9	0.0%
Vocational/Adult Education	15.4	16.4	9.1	-44.5%
Bilingual Education	2.6	2.6	2.6	0.0%
International Education and Foreign Language Studies	1.5	2.0	2.0	0.0%
Science and Math Programs of National Significance	0.5	0.5	0.0	0.0%
Fund for the Improvement of Postsecondary Education	0.4	0.4	0.5	25.0%
Secretary's Discretionary Fund	0.0	0.0	0.0	0.0%
All Other	16.1	19.6	25.1	28.1%
TOTAL, Conduct of R&D	$145.6	$160.2	$162.9	1.7%
R&D Facilities				
Howard University	1.8	1.8	1.8	0.0%
TOTAL, Facilities	$1.8	$1.8	$1.8	0.0%
TOTAL Education R&D	$147.4	$162.0	$164.7	1.7%

Source: Agency FY 1991 budget justification.

Part III: Disciplinary Analyses

Introduction

The chapters that follow take a cross-cutting view of the FY 1991 figures for R&D to the preceding agency chapters -- summarizing the R&D prospects for some of the major scientific and engineering disciplines and research areas. In each case, the budgets of various agencies which provide support for these disciplinary areas are examined, and policy issues and funding trends are discussed in terms of their impacts on the disciplines. Tables in these chapters, on the whole, contain detail of agency R&D programs not shown in the tables that appear at the end of Part II.

Chapter 12

Physics in the FY 1991 Budget

American Institute of Physics

Richard M. Jones, Marguerite P. Mulhall

President Bush's fiscal year 1991 budget request gives unusual prominence to high energy physics and the Superconducting Super Collider (SSC) in this year's formal budget document. In a chapter entitled "Expanding the Human Frontier," the Administration declares its support for high energy physics and the SSC by declaring:

> The history of science shows that many major advances in [the] fundamental understanding of natural process have led to technologies, products and processes that ultimately improve the quality of life for our citizens and enhance the economic competitiveness of the nation. The SSC is a critical part of the Administration's initiative to strengthen America's position as a world leader in science and technology.

Determining whether federal support for physics-related research is "up" or "down" depends upon one's perspective. The Administration continues its support for the SSC and the Strategic Defense Initiative. Other areas of the budget for physics research, most notably the National Science Foundation, appear less strong.

The Department of Energy, National Science Foundation, Department of Defense, and the National Institute of Standards and Technology provide major support for physics.

I. Department of Energy

The Department of Energy's budget request for FY 1991 increases 6.4 percent over FY 1990 to $17.5 billion. The request includes funding for a wide range of activities such as: cleanup of DOE weapons facilities, which increases 26 percent to $2.8 billion; funding for the Superconducting Super Collider, up 46 percent to $317.9 million; participation in the U.S. Global Change Research Program, $65.9 million; development of capabilities to map the human genome structure, up from $26 million to $46 million, and support for precollege programs for elementary and secondary schools in science and math, up $8 million over last year to a total of $11 million.

The Bush budget stresses the need for "managing by objectives." The four major objectives outlined for DOE are: 1) to support the nation's nuclear deterrent into the next century (with protection of the environment and safety and health being placed on a par with production); 2) to provide cleanup of waste at DOE facilities across the nation; 3) to develop and execute an integrated market-based National Energy Strategy; and 4) to construct the Superconducting Super Collider accelerator on schedule and within established estimates of cost (with one-third of the cost to come from non-federal sources).

- Superconducting Super Collider (SSC):

President Bush, now being proclaimed the "Science President," has given the SSC a prominent position in his budget document. Office of Management and Budget Director Darman's introduction to the budget includes a three-page section entitled, "Unlocking the Secrets of Matter and Energy: High Energy Physics and the Superconducting Super Collider," which describes current endeavors in high energy physics and plans for the SSC.

The $317.9 million requested for FY 1991 will continue R&D on magnet design, testing and fabrication, design and testing of other collider technical systems and detector R&D. Construction funding requested in 1991 will be used for the magnet industrialization program and the first major technical systems fabrication. The total cost of the SSC was estimated at $5.9 billion with contributions from non-federal sources, including the state of Texas and foreign sources, expected to fund one-third, or about $1.8 billion. However, recent design reviews have indicated significantly higher cost estimates ($1.3 billion higher), and foreign participation must wait until Congress has received a full report on such international contributions.

- High Energy Physics:

High Energy Physics funding is up 7 percent to $621.2 million. Of this, $278.7 million is provided for facility operations; $140.3 million to support university and laboratory-based groups in experimental and theoretical research; and $75.2 million for high energy physics technology for existing facilities. Capital equipment receives $88.2 million; construction funding is $38.8 million with $12.3 million for general plant projects, $14.5 million for accelerator improvements, and $12 million for the Fermilab Linac Upgrade (with a total estimated cost of $22.8 million).

- Nuclear Physics:

Nuclear Physics increases 14 percent to $330.7 million. This figure includes $65 million in continued support for construction of the Continuous Electron Beam Accelerator Facility (CEBAF) with total cost estimated at $265 million, and $15 million to initiate construction of the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory, at a total estimated cost of $397 million. Operating expense program support is $215.5 million, which includes the subprogram activities of Medium Energy Physics ($101 million), Heavy Ion Physics ($72.9 million), Low Energy Physics ($28.1 million) and Nuclear Theory ($13.5 million).

- Magnetic Fusion:

The FY 1991 request for magnetic fusion is $325.3 million, only one percent above FY 1990. This year (1990), Secretary of Energy Watkins is appointing a Fusion Policy Advisory Committee to review and recommend a fusion policy for both magnetic and inertial confinement approaches. The budget language states, "The 1991 budget request represents an attempt to preserve an amount of funding which does not in any way try to presume the eventual conclusion of the review." The program balance continues as in FY 1990, with a focus on confinement fusion. The Compact Ignition Tokamak receives only $16.8 million.

- Basic Energy Sciences:

Basic Energy Science funding is up 14 percent to $648.7 million. Subprograms receive funding as follows: materials science ($221.9 million), chemical sciences ($150.5 million), applied mathematical sciences ($48 million), engineering and geosciences ($32.5 million), energy biosciences ($20.2 million), and advanced energy projects ($24 million). The 12 GeV synchrotron radiation source at Lawrence Berkeley Lab will be largely completed with the FY 1991 funding of $23 million. Construction continues on the 6-7 GeV synchrotron radiation source with FY 1991 funds of $75 million. In addition, $25.7 million is provided for R&D costs for these facilities.

University Research Instrumentation is down slightly from $4.930 million in FY 1990 to $4.924 million in FY 1991.

University Science and Education receives $29.8 million, up about $5 million. However, from this amount will come the $8 million increase in pre-college activities.

II. National Science Foundation

The budget request for the National Science Foundation (NSF) provides significant growth over FY 1990. A 14 percent increase over FY 1990 is requested, or $299 million in additional funding. The commitment of the Reagan and Bush Administrations to double NSF's budget remains unchanged.

- Mathematical and Physical Sciences Activity:

NSF provides support for physics under the "Mathematical and Physical Sciences" activity, which would increase by 11.6 percent.

The Administration requested $621.5 million for Mathematical and Physical Sciences for FY 1991. This is $64.5 million more than the FY 1990 current plan provides, and is $68 million more than requested for FY 1990.

NSF proposes a Laser Interferometer Gravitational Wave Observatory consisting of two identical, but widely separated, next-generation detectors. Total estimated cost over four years will be $192 million. NSF expects other countries to construct similar detectors. In addition, two 8-meter optical/infrared telescopes are planned, one in each hemisphere. Completion is planned in eight years at a total cost of $176 million. The U.S. will pay half, with foreign participation expected to fund the remainder. Funding for these facilities is provided under a separate subactivity from that for physics.

- Physics Subactivity:

Physics is not an identified "area of growth" identified in this year's budget. Although NSF's Mathematical and Physical Sciences activity request increases by 11.6 percent, physics support would increase by only 5.2 percent.

Physics funding shows the smallest increase of any subactivity in the Mathematical and Physical Sciences activity, which ranged from 5.2 percent to 86 percent.

In overall dollar support, NSF's FY 1991 request would provide the greatest funding for physics of any of the subactivities under this overall activity of $130.2 million Table I highlights changes in the FY 1991 budget:

TABLE I
NATIONAL SCIENCE FOUNDATION
BUDGET SUMMARY OF OBLIGATION FOR PHYSICS: FY 90/FY 91

Actual FY 1989:	$122,284,000
Request 1990:	129,998,000
Current Plan (FY 1990):	123,831,000
Estimate FY 1991	130,230,000
Difference (1991/1990)	
Amount	6,399,000
Percent	5.2%

The increase in physics support between "actual FY 1989" and "current plan, FY 1990" is approximately one percent.

Table II provides a breakdown of NSF's funding request for physics. In comparing the FY 1990 and FY 1991 budget requests, NSF support for elementary particle physics and nuclear sciences declines. Gravitational physics receives the largest percentage increase (See Table II).

III. Department of Defense

Despite changes in the Soviet Union and Eastern Europe, the basic research programs budget for the Department of Defense has not declined. At least some of this can be attributed to the Administration's stated objective of guarding against technological surprises.

- Overall Funding Levels

The Administration requested an additional 5.9 percent for defense basic research programs in FY 1991 (including Department of Energy programs.) In FY 1991 approximately $977 million would be spent for defense basic research. This figure includes $98.7 million for the Universities Research Initiatives to strengthen the relationship between DOD and academic institutions. The FY 1990 request for this program was $96.1 million.

An overall increase of 4 percent in defense R&D (DOD and DOE) was requested, for a total of $41.4 billion. Most of this is for specific weapons programs and supporting systems.

Budget authority levels for RDT&E for the Defense Department (only) are as follows:

FY 1988	$36.5 billion
FY 1989	37.5
FY 1990	36.8
FY 1991	38.0

The total defense budget request for FY 1991 is up by 1.7 percent.

TABLE II National Science Foundation FY 1991 Physics Research and Development Budget in the Mathematical and Physical Sciences Program

	FY89 actual	FY90 request	FY90 current	FY91 request	% Change FY91/FY90
	(in millions of dollars)				
Physics					
Elementary Particle	$40.11	$43.43	$39.83	$41.33	3.8%
Nuclear	41.90	44.71	42.00	43.50	3.6%
Atomic, Molecular & Optical	13.87	14.42	14.30	15.40	7.7%
Theoretical	16.62	17.08	17.40	18.70	7.5%
Gravitational	9.79	10.35	10.30	11.30	9.7%
TOTAL.	$122.28	$130.00	$123.83	$130.23	5.2%
Materials Research					
Project Support	$64.83	$69.61	$66.06	$69.16	4.7%
Laboratories & Groups	34.22	36.20	34.55	36.90	6.8%
Facilities & Instrumentation	16.03	17.37	16.33	17.40	6.6%
TOTAL.	$115.08	$123.18	$116.94	$123.46	5.6%
COMBINED TOTAL	$237.36	$253.18	$240.77	$253.69	5.4%

This budget continues the shift away from defense R&D to civilian R&D. In FY 1986 defense R&D was 69 percent of all federal R&D, declining to 61 percent in FY 1991.

- Physics

Determining research support for physics has traditionally been difficult. Table III provides funding levels and requests for the Army, Navy, Air Force, DARPA, and the Office of Secretary of Defense under the 6.1 budget category.

The greatest percentage increases are proposed for the Air Force and Navy laboratories; the largest actual increase ($32.8 million) would be for the Navy's research sciences, including physics and materials. No increase was requested for DARPA's semiconductor cooperative research (SEMATECH), even though this has been cited as an "important example" of government-industry cooperation and a "prerequisite for our future national well-being" by the Administration. The budget was cut for the Air Force's geophysics activities, and no funding was requested for the high-frequency active auroral research program under the Office of Secretary of Defense.

- Strategic Defense Initiative

The FY 1990 SDI appropriation of $3,571.2 million was a seven percent real reduction from that approved in the previous year (FY 1989). This appropriation was 78 percent of the $4.6 billion requested. As a result, DOD stretched out the SDI program, with some projects cut or terminated.

The total RDT&E FY 1991 budget request for the nine SDI participants is $4,460.0 million. Although less than the FY 1990 request, it is much greater than the actual appropriation.

The Administration's budget provides for the initial deployment of Phase I elements in the late 1990s, consisting of space-based (Brilliant Pebbles) and ground-based interceptors with supporting systems. Major direct energy experiments (Free Electron Laser, Chemical Laser, and Neutral Particle Beam) are included in the FY 1991 budget request.

IV. National Institute of Standards and Technology

The Administration requests a $36.5 million increase for the National Institute of Standards and Technology (NIST), the largest single increase since this Commerce Department agency was established. NIST is the only federal laboratory with a primary mission of assisting American industry.

Four major technology areas would receive greater support under the budget request: chemical measurements, information technologies, electronic technology, and intelligent machines and standards. Of particular interest to the physics community are the following:

- Information Technologies

An additional $5.5 million is requested for lightwave measurement technology to provide assistance for the accelerated development of data and standardized measurement methods.

The integrated services digital network (ISDN) budget would be increased by $1 million. This technology combines voice, video, and data in a single technology.

A $2.5 million increase is requested for computer security programs for research, standards development, and technical assistance programs.

- Electronic Technology

Advanced semiconductor measurement support would be increased by $3.9 million for the next generation of integrated circuits.

An additional $1.9 million is requested for high-temperature superconductor research to increase NIST measurement support to U.S. industry.

Atomic-scale electronics basic research would receive an additional $1 million to investigate the fundamental physical limits on the size of microelectronic devices.

Chapter 13

Astronomy in the FY 1991 Budget

American Astronomical Society

Peter B. Boyce

I. Highlights of the Astronomy Budget

There is good news and bad news. The budgets for NSF and NASA are better than they have been for years, but the overall budgetary pressures make it almost certain that Congress will have to cut back the requested increases. While generally healthy for astronomy, the NASA budget is somewhat confused by the uncertainty of planning which seems to mark its three large programs: the Space Station, the Earth Observing System and the Human Exploration Initiative. NSF continues to give a low priority to the physical sciences, including astronomy.

- NSF, having received special funds in 1989 and 1990 for rebuilding the Green Bank Telescope which collapsed in 1988, has converted those funds, in 1991, into a special budget line for major instruments in the Mathematical and Physical Sciences Directorate. In 1991, these funds will be used for beginning construction of two eight-meter optical telescopes, a gravitational wave observatory, and a low-temperature, high-magnetic, field facility for solid state physics.
- The major NASA missions such as the Advanced X-ray Astronomy Facility (AXAF), the Comet Rendezvous/Asteroid Flyby (CRAF) and the CASSINI mission to Saturn will continue to be funded at appropriate levels.

- Overall cuts in the FY 1990 budget, expensive launch delays and overruns have caused severe reductions in the research grant program of the NASA Planetary Exploration Division. If similar problems can be avoided in FY 1991, the program should receive enough of an increase to restore it to health.
- Several astronomy missions have been launched in 1989 and more will come in 1990; expensive storage costs will finally be a thing of the past in 1991. Data, as well as the money to analyze it, will start finding its way into the community in 1991.
- NASA's space science budget does not include money for funding a new airborne observatory known as SOFIA (Stratospheric Observatory for Infrared Astronomy).

II. Introduction

As in previous years, we will limit our analysis of the astronomy budget to the two agencies which provide over 90 percent of the federal funding for astronomical research, NASA and NSF. Other agencies, such as the Smithsonian Institution, the Department of Defense, the Department of Energy, etc., also fund research of interest to astronomy, but these play a minor role in the overall picture of federal support for astronomy.

III. Astronomy in the NASA Budget

This is an exciting time for astronomy at NASA as a large backlog of science missions is in the process of being launched. 1990 and 1991 will see as many new science missions as there were in the entire previous decade. The budget for mission operations will increase significantly. As part of the operating cost, the funding to the scientific community to analyze the data will also increase. NASA's science interests are turning toward the Earth Observing System and the Human Exploration Initiative, both of which include significant funding for current programs which have been reclassified. If Congress cuts back on these new, large initiatives, several ongoing NASA activities stand to be hurt.

Under the present organization of NASA's Office of Space Science and Applications it is difficult to specifically identify the funding for astronomy. In particular, a comparison with budgets earlier than 1988 is meaningless. However, the general emphasis on astronomy within Physics and Astronomy remains about the same, so the size of the items within that line indicate the general trend of astronomy funding within NASA. Planetary Exploration retains its separate identity, and accurately tracks the funding for planetary astronomy within the agency.

The NASA budget tables are given elsewhere in this volume. The following NASA budget lines may need explanation:

Payload and Instrument Development is designed to accommodate development of specific instruments to be flown on the shuttle, as free-flyers or on foreign flights.

Spacelab Payload Mission Management & Integration provides support for the planning, integration and execution of all Spacelab and attached shuttle payloads. This includes payload specialist training, payload flight operations and data dissemination to the experimenters.

Space Station Planning and Payloads covers the planning and definition of attached payloads suitable for deployment on the Space Station.

Mission Operations and Data Analysis supports the operating costs of current missions and funds the analysis of data from current and past missions. The entire scientific output of a mission is supported by these funds.

Research and Analysis supports general research relevant to NASA's missions and provides the advanced technology development needed to plan future missions. Funding for early exploratory work on the difficult, pacing items for future missions, such as the Space Infrared Telescope Facility (SIRTF), fall in this budget line, as does the Astrophysics Theory Program and grants to individual investigators.

Suborbital Programs supports the flights of aircraft, balloons and rockets. These vehicles provide low-cost platforms for developing instrumentation and provide frequent opportunities for making vital supporting observations.

The FY 1991 NASA budget provides strong support for a program of space science which is balanced between provision of hardware and support of operations and data analysis:

- The combined CRAF/CASSINI mission to an asteroid, a comet and the Saturn system was started last year at a low level and will receive a major increase as the project enters the construction phase.
- Fabrication of the mirrors for the third Great Observatory Mission, AXAF, is continuing in 1991. The mirrors and other high-technology items are supposed to be well in hand at the end of next year. At that point, construction is planned to begin on the spacecraft itself.
- The Hubble Space Telescope (HST) launch has been delayed until April, 1990. At a cost of $300,000 per day, the unbudgeted additional expense will amount to $27M.
- Launch of the Gamma Ray Observatory, another Great Observatory mission, will be delayed until November.
- Operations of the Magellan and Galileo missions, launched in 1989, were more expensive than budgeted in FY 1989. The Mars Observer mission required more funds than expected in FY 1990, but will continue to receive the funding needed to keep the mission on schedule for a 1992 launch. The Planetary Research and Analysis budget was cut to make up for these shortfalls. The R & A budget should recover in FY 1991, provided that similar shortfalls and cuts do not occur again.
- The Explorer program has an increase of nearly $10 million. Development of the Extreme Ultraviolet Explorer and the X-Ray Timing Explorer will continue. The Cosmic Background Explorer (COBE), launched last year, is working well. Preliminary data has been of remarkably high quality.
- The Mission Operations and Data Analysis funds will increase to cover the costs of operating the new missions and analyzing the data which is starting to be produced.
- Funding for the STORE shuttle test of concepts which could lead to the Gravity Probe - B mission, which was cut and then restored by Congress last year, has been included in the budget this year.
- A new specific program to make it easier for U.S. scientists to build and fly instruments on foreign missions, although desired by the agency and the scientific community, is not included in the budget, which will cause a significant problem in FY 1991.

- The first flight of the ASTRO mission on the shuttle is finally scheduled for May, 1990, but planned second and third flights have been canceled.

IV. Astronomy in the NSF Budget

NSF, which received $37.5M in both 1989 and 1990 in the form of special funds to rebuild the Green Bank telescope which collapsed, has incorporated that money into a special budget line for the funding of major instruments in the Mathematics and Physical Sciences Directorate. This marks a major step in the agency's ability to plan and fund major equipment for a field such as astronomy on a reasonable time scale without severely undercutting the ongoing core programs.

Despite the increase in construction money, support for the core programs in astronomy at NSF continues at a rate which is below inflation. The cumulative effect of five years of static funding for an expanding field is hurting the U.S. ground-based astronomical research effort. At the same time, the demand for ground-based observations in support of NASA missions will further increase the pressure for use of facilities which are already oversubscribed by a factor of three or higher.

Within the National Science Foundation, most astronomical research is supported within the Division of Astronomical Sciences. What support there is for astronomical research in other divisions is not specifically enumerated in the budget.

Through contractors, NSF operates three National Observatories which are available to qualified scientists under an extensive visitor-use program. The National Observatories have major telescopes and some smaller instruments which have been among the most productive in the world. Under Astronomy Research Support, NSF has a program of peer-reviewed research grants to individual investigators and to research groups located at universities and research observatories.

The NSF FY 1991 budget table for astronomy is given below. The significant aspects are as follows:

- Astronomy received an overall budget increase of 9.9 percent from 1989, but the core programs exclusive of construction projects will see increases near five percent. If last year's experience is any guide, this will be cut back to two percent, well behind the inflation rate.

- Construction of the Very Long Baseline Array will continue at a reduced rate of $11.0 million. Completion of the project is expected by 1993. Other Observatory operations will continue to face very severe budget constraints.
- Within the National Optical Astronomy Observatories, funds will be provided from the new Major Equipment Construction line for the designing of two eight-meter optical telescopes, one for each hemisphere. Full funding is contingent upon finding two international partners to share the construction cost. Construction of the solar Global Oscillations Network will continue at a very reduced pace. Operating funds for the observatories will remain at a crisis level. The proposed budget levels preclude, once again, the payment of the costs of travel and publication of research results for visiting astronomers from around the country. Astronomers from small institutions are hurt the most by this.
- The National Astronomical and Ionospheric Center will receive funds to begin a major upgrade of the 1000-foot diameter radio telescope in Arecibo. Half the funds for this upgrade will be supplied by NASA.
- In the Astronomy Project Support Section, which funds the university grants program, increases are also kept to five percent. Within this section the distribution of money among the programs is driven by proposal pressure and by transfer of responsibility for the larger grants from program to program as the emphasis shifts from instrumentation to research on stars, or to extragalactic research, or back to instrumentation. The budget requests for the individual programs of research grants do not reveal specific shifts in emphasis by the agency and, therefore, have not been listed separately.

NSF Astronomy Funding (in millions of dollars)

	FY 1989 Actual	FY 1990 Plan	FY 1991 Request
Total NSF Astronomy	$ 89,224	$ 91,647	$ 100,700
Astronomy Project Support	28,651	30,420	31,910
National Observatories	60,573	50,227	57,790
NAIC	6,187	6,267	11,270
NOAO	24,321	24,620	25,770
NRAO Operations	30,065	19,340	20,750
VLBA Funding		11,000	11,000

Chapter 14

FY 1991 R&D in the Atmospheric and Oceanic Sciences

American Meteorological Society

H. Frank Eden

INTRODUCTION

The FY 1991 budgets for Atmospheric and Oceanic Sciences are affected by two activities that tend to make the distinction of funding between the two disciplines more difficult than in previous years. The first of these is the interagency Committee on Earth Sciences' very successful process that developed the coordinated, interdisciplinary U.S. Global Change Research Program for FY 1990 and FY 1991. This cross cuts many agency budgets and makes no distinction between atmospheric and oceanic research. Tracking into the disciplines is still possible in most agencies but complicated. Secondly, in NASA the Earth Sciences and Applications Division of OSSA has reorganized along interdisciplinary lines (merging the old disciplinary research and analysis funds) and, moreover, has a major new start. That is the Earth Observing System (EOS), a multidisciplinary system for observing and documenting the change of many global variables. Some missions such as UARS and TOPEX can still be assigned on a disciplinary basis, but a large portion of the NASA budget cannot be so assigned in FY 1991. Probably in subsequent years it will be possible to make the distinction. Accordingly, the usual cross-cut table is included in this chapter but not totalled and without a NASA line. In general, however, it is clear from all agency budgets that the FY 1991 proposal requests significant increases for both disciplines.

At NSF, Atmospheric Sciences increases by 15.4 percent from $104.1 million in FY 1990 to $120.1 million in FY 1991.

TABLE III Department of Defense basic research funding (6.1 budget category)

	FY89 actual	FY90 current	FY91 request
	(in millions of dollars)		
Army			
Research, including physics and materials	$170.9	$172.6	$179.5
Army laboratories discretionary research	----	$8.9	9.4
Navy			
Research, including physics and materials	$329.0	$341.6	$374.4
Navy laboratories discretionary research	23.4	24.3	26.8
Air Force			
Research, including physics and materials	$190.3	$182.2	$193.2
Air Force laboratories discretionary research	6.9	7.5	8.3
Geophysics	36.1	36.9	36.5
Defense Advanced Research Projects Agency			
Research including physics and materials	$86.6	$78.2	$85.2
Semiconductor cooperative research (SEMATECH)	100.0	100.0	100.0
Office of the Secretary of Defense			
Universities research initiatives	$95.0	$96.0	$98.7
High-frequency active auroral research program	-----	10.0	-----

Ocean Sciences increases by 16 percent from $147.4 million in FY 1990 to $171 million in FY 1991.

At NASA, support in the Earth Science and Applications Program increases, due to the new start for EOS and transfer of responsibility for polar platform, by 43.9 percent from $439.3 million in FY 1990 to $661.5 million in FY 1991. This includes $68 million for TOPEX and $66 million for UARS. The budget proposes a new start for the Earth Observing System (EOS) at $103.2 million. Responsibility for Polar Platform ($132 million) has been transferred to OSSA for increased efficiency in designing the platform in conjunction with EOS development. Upper atmosphere research is now supported through Physics and Astronomy and includes $98.5 million for the Global Geospace Science Mission.

At NOAA, the budget proposal for FY 1991 of $1.39 billion in direct obligations for Operations Research and Facilities represents an increase over the FY 1990 base of $1.36 billion. There are increases in Oceanic and Atmospheric Research, the National Weather Service and the National Environmental Satellite, Data and Information Service and decreases in the National Ocean Service and National Marine Fisheries Service. The budget includes $87.0 million for Climate and Global Change.

National Aeronautics & Space Administration (NASA)

NASA's overall budget increases by 23 percent to $15.1 billion in FY 1991 and initiates the EOS and the Human Exploration Initiative aimed at explorations beyond Earth's orbit (e.g., Mars). It also includes the development start for the Earth Probes, including TOMS and TRMM. The Earth Science and Applications Program, now reorganized along interdisciplinary lines, shows slightly reduced project costs in FY 1991 for the Ocean Topography Experiment, TOPEX, ($68.0 million) and the Upper Atmosphere Research Satellite, UARS, ($66 million). Support for the essentially completed Scatterometer is continued at $3.7 million in anticipation of the instrument flying on the Japanese ADEOS project in 1995. The old Research and Analysis disciplinary funds are now contained in Modelling and Data Analysis and Process Studies and show a modest increase of 5.3% to $152.4 million. EOS is begun at $103.2 million.

For consistency with previous years, programs that relate to upper atmosphere research now contained in the Physics and Astronomy Program are noted also. The Global Geospace Science Mission increases to $98.5 million in FY 1991, as part of the U.S. contribution to the International Solar Terrestrial Physics Program (ISTP). Approximately 20 percent of the Research and Analysis support in the Physics and Astronomy Program is for space science. Similarly, a significant portion of the Sub Orbital Program of sounding rockets, airborne science and balloon launches is in support of atmospheric sciences.

National Science Foundation (NSF)

The overall FY 1991 request for NSF is at $2.38 billion, an increase of 14 percent over the FY 1990 appropriation. This is in line with the Administration's commitment to doubling the NSF budget over five years.

Increases in Atmospheric Sciences Project Support in FY 1991 are primarily in portions of the Global Geosciences initiative ($8.57 million), including enhancements for major field programs in the Global Tropospheric Chemistry Program, and the Tropical Ocean and Global Atmosphere (TOGA) program, and the Coupling, Energetics and Dynamics of Atmospheric Regions (CEDAR) Programs.

The Upper Atmosphere Facilities program will provide enhanced support ($1.16 million) for CEDAR. At NCAR, an increment of $4.64 million will emphasize Global Geosciences programs and increased cost of operations.

Of the FY 1991 increment of $23.63 million in Ocean Sciences, Global Geosciences programs will receive $19.2 million for WOCE, JGOFS, RIDGE and TOGA-COARE.

In the Ocean Drilling Program (ODP), incremental support will emphasize high temperature techniques, high latitude programs and increased analysis of lugging data. The Centers and Facilities Program will complete the conversion of R.V. Bernier.

The above figures do not include support for the Atmospheric and Oceanic Sciences from the Division of Polar Programs. In the Arctic Research Program the FY 1990 level of support for research projects is $12 million of which about 30 percent is for atmospheric and oceanic research. The total rises to $16.1 million in FY 1991. The increase is in support of the Arctic Systems Sciences effort, ARCSS ($3.1 million) and Arctic social science ($1 million). About half of the ARCSS increase is for atmospheric and ocean sciences. Antarctic Program support for atmospheric and oceanic research is approximately 40 percent of the Antarctic Research Program's budgets of $17 million in FY 1990 and $19 million in FY 1991 with an increase across the geosciences.

Department of Defence (DOD)

The budget projections for DOD are estimates based upon FY 1989 obligation, FY 1990 organizational budgets and the FY 1991 budget submission. The FY 1990 and the FY 1991 estimates are subject to change.

Army research in atmospheric sciences focuses strongly on the planetary boundary layer and support to Army weapon systems. Research includes theory and technique development to document atmospheric effects on electro-optical and infrared propagation, focussing on the battlefield environment. Research in airflow in complex terrain and atmospheric transport and diffusion address a broad front of Army and DOD needs. Exploratory work to evaluate new sensor technologies, such as profiler radar and lidar, continues in efforts to develop battlefield remote sensing capabilities. A centerpiece of the Army development program is the integration of weather events and effects into the Air-Land Battle concept. A substantial effort to develop standard scenes for the evaluation and testing of weather-sensitive smart weapons is not included in budget summary, but would add about $5 million each year, if classed as atmospheric sciences.

The Air Force research program also focuses on a wide breadth of research needs. In large-scale dynamic modeling, the fidelity of Air Force global and regional prediction models for highly reliable cloud forecasting is being emphasized. On a more limited scale, research is continuing on refining atmospheric electro-optical and infrared propagation codes and the development of electro-optical/infrared systems tactical decision aids. In other areas, emphasis is being placed on satellite and ground-based remote sensing capabilities, such as satellite vertical sounding for temperature and water vapor, upper atmospheric density, and the development of algorithms for the NEXRAD radar. Technology development continues in the area of advanced meteorological data processing incorporating expert systems concepts to fuse data from various sources, i.e., radar, satellite and other ground-based sensors.

Atmospheric science research funded by ONR consists of two primary thrusts, marine planetary boundary layer and oceanic storms. Marine boundary layer research is directed toward understanding the physical processes governing the evolution of the lowest 2 km of the atmosphere over the ocean and in coastal regions. Oceanic research has two major components, midlatitude extratropical cyclogenesis and western Pacific tropical cyclones. In other areas, efforts are underway to introduce new capabilities in meteorological and oceanographic data acquisition, processing and presentation through the introduction of the third generation Tactical Environmental Support System (TESS-3) to major combatant ships.

Oceanographic research includes small-scale physical oceanography, mesoscale and large-scale circulation and structure, ocean geophysics (bottom characterization, thermal vents), ocean acoustics (noise sources and character, acoustic propagation), and ocean biology. Ocean circulation efforts ultimately focus on the development of eddy-resolving global and regional oceanographic numerical models. The increase in FY 1991 reflects the emphasis being placed on ocean sciences by ONR.

Not specifically included in the budget table is funding for the DOD University Initiative (URI) programs in atmospheric and ocean sciences. In FY 1990, approximately $9.6 million is funding URI programs in atmospheric, ocean and space environmental sciences.

National Oceanic & Atmospheric Administration (NOAA)

The NOAA request for FY 1991 of $1.39 billion for Operations, Research and Facilities represents a significant increase in budget authority over FY 1990 and a modest increase in actual obligations. There are a significant reduction in the National Marine Fisheries Service and significant increases in the National Weather Service, in Oceanic and Atmospheric Research, and in NESDIS. Major new support is proposed for Climate and Global Change.

In the National Ocean Service, the Ocean and Coastal Management program and Ocean Observation and Assessment activities are reduced. The Coastal Ocean Science program increases by $11 million to $17.4 million.

In the National Marine Fisheries Service, almost all programs have been reduced.

In Oceanic and Atmospheric Research, the Climate and Global Change program funding is $87 million. PROFS research is reduced by $2 million. Regional Climate Centers, Weather Modification Grants, Seafloor Processes Research, Undersea Research, and the National Coastal R & D Institute are terminated. Sea Grant is reduced by $13.3 million to $27.5 million.

The National Weather Service is proposed for an increase of $25 million. NEXRAD and related procurements increase by $43.2 million, and acquisition of AWIPS equipment is increased by $21.4 million. The Special Agricultural Weather Services are terminated.

In the National Environmental Satellite, Data, and Information Services (NESDIS), the FY 1991 request increases by approximately $15 million but provides for maintaining a geostationary satellite (GOES) system and a polar-orbiting satellite system and for the launch of Landsat 6. Funds for Landsat commercialization are increased by $1.6 million.

Program Support increases by approximately $13 million in FY 1991. The Fleet Rehabilitation Program increases by $5.7 million for modernization and to reactivate DAVIDSON, and an increase in Aircraft Service allows for navigation system components for the P-3's.

Other Agencies

Atmospheric Sciences:

Funding for research in FAA decreases significantly in FY 1991. Program emphases are shifted to implementation of research results and operational support.

In EPA, funding for atmospheric research on acid deposition decreases as projects under NAPAP reach completion. There is an increase in research devoted to climate, regional ozone modeling. The formation and fate of acidic aerosols and the exploratory research program in general atmospheric sciences. Other components of the program remain level.

In DOA, the increase in the FY 1990 budget reflects an expanded program aimed generally at global change issues including UV-B studies, ecosystem modeling and biogeochemical cycles. The rest of the budget supports basic research in climatology, upgrades to the SNOTELL joint agricultural weather facility and strengthened meteorological data handling.

The DOE program in atmospheric sciences of the Office of Health and Environmental Research (OHER) covers over 95 percent of DOE support in this area. The major portion of the OHER budget involves studies dealing with global change including the CO2 studies. The latter studies have recently been transferred from the Office of Basic Energy Sciences to OHER. Atmospheric research in OHER also consists of atmospheric chemistry studies, the atmospheric effects of complex terrain, and emergency response research. The sharp increases in funding over the three years are due to global change studies.

In BUREC, the weather modification program was virtually eliminated except for reimbursable work of $0.25 million in FY 1989. In FY 1991, the program achieves some growth. The Bureau of Reclamation's FY 1991 precipitation management (weather modification) research program continues to focus on two principal objectives: (1) validation of precipitation management (including cloud seeding) as a practical water supply augmentation measure, and (2) transfer of precipitation management technology to non-federal entities, including state and local authorities, for application. Other Department of Interior programs -- effects of biological pollutants, acid deposition monitoring, and modeling -- are stable at about $10 million annually. These programs have generally not been reported in this analysis.

Ocean Sciences:

In the U.S. Geological Survey, there was an increase in FY 1990 in the Coastal Erosion and Wetland Loss Program, while EEZ and geological framework studies remain level funded. There is essentially no change in FY 1991 in offshore geologic framework studies, in EEZ research, and in coastal studies.

In DOE, the funds support basic oceanography, including shelf edge studies, aspects of radioisotope studies, and ecological studies. There is an enhancement in FY 1991 with the primary thrust aimed at research on transport across continental shelves and cooperation with the Global Ocean Flux Study, GOFS.

Research projects supported through the Environmental Studies Program (ESP) of the Minerals Management Service (MMS) provide the information necessary for the MMS to make environmentally sound decisions concerning leasing and exploitation of oil and gas resources in the U.S. Exclusive Economic Zone. These studies are classified in nine topic areas with emphasis on biology, endangered species, fates and effects, and physical oceanography with the majority of the studies contracted out as competitive procurements.

MMS's FY 1989 and planned FY 1990 and 1991 ESP budgets exceed $20 million per year. The program is very heavily ocean directed with a small effort on air quality. The program is reported here totally as oceanic.

The Environmental Protection Agency (EPA) supports a program of Coastal Environmental Management to provide scientific and technical support for state and local management of coastal water quality in response to risks due to pollution and loss of habitat. Regional efforts include the Gulf of Mexico program.

The National Acid Precipitation & Assessment Program

This ten-year interagency program, chaired jointly by the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, and the Departments of Agriculture, Energy, and the Interior, was created by Congress in 1980 (Pub. L. 96-294) to coordinate all federally funded acidic deposition research. NAPAP will conclude in FY 1990 with the completion of its State of Science/State of Technology reports and public release of the Integrated Assessment report. Presumably, many of the atmosphere- and ocean-related programs now conducted as part of NAPAP will continue as ongoing efforts within the individual agencies.

Table 1. R & D in the Atmospheric and Ocean Sciences (Budget Authority in millions of dollars)

	FY 1989 Actual	FY 1990 Estimates	FY 1991 Estimates
Atmospheric			
NASA[1]	-----	-----	-----
NSF	$ 98.6	$104.1	$120.1
DOD	75.3	70.2	68.9
DOC (NOAA)	89.5	98.8	102.7
DOE	20.8	46.3	60.4
EPA	20.1	19.7	19.3
DOT (FAA)	14.9	13.1	8.8
DOA	11.6	14.9	40.3
DOI (BUREC)	0.3	0.0	0.7
Oceanic			
NASA	-----	-----	-----
NSF	145.9	147.4	171.0
DOD	89.3	88.1	96.9
DOC (NOAA)	80.8	86.1	99.0
USGS	29.5	30.7	30.4
DOE	5.8	5.5	6.9
MMS	20.9	20.0	23.8
EPA	16.2	21.1	34.9

[1] It is not possible to divide the FY 1991 NASA budget accurately between the two disciplines.

Table 2. R & D in NASA's Atmospheric and Ocean Sciences
Earth Science and Applications

	FY 1989 Actual	FY 1990 Estimates	FY 1991 Estimates
Earth observing system	----	----	$103.0
Polar platform	$ 20.4	$ 74.0	132.0
Earth probes	----	----	25.0
Upper atmosphere research satellite mission	85.2	64.2	66.0
Ocean topography exper.	83.0	80.8	68.0
Scatterometer	10.6	13.6	3.7
Payload and instrument development	46.4	76.1	49.7
Mission operations and data analysis	17.6	23.9	30.4
Interdisciplinary research	2.2	8.6	2.4
Modeling and data analysis	34.1	38.5	41.3
Process studies	93.7	106.2	111.1
Laser research facilities	7.6	8.0	8.7
Airborne science and applications	23.0	19.4	20.2
TOTAL	$403.4	$ 39.3	$661.5
Physical Astronomy Program			
Global geospace science	$ 64.4	$ 67.2	$ 98.5
Research and analysis	85.1	109.5	122.5
Suborbital program	45.4	52.7	55.0
Space physics mission operations and data management	11.6	21.1	20.9
TOTAL	$206.5	$250.5	$295.9

Table 3. R & D in NSF's Atmospheric Sciences

	FY 1989 Actual	FY 1990 Estimates	FY 1991 Estimates
Atmospheric Science Project Support	$ 49.9	$ 53.2	$ 63.4
National Center for Atmospheric Research	43.7	45.3	50.0
Upper Atmospheric Research Facilities	5.0	5.6	6.8
TOTAL	$ 98.6	$104.1	$120.2

Table 4. R & D in NSF's Ocean Sciences

	FY 1989 Actual	FY 1990 Estimates	FY 1991 Estimates
Ocean Sciences Project Support	$ 70.9	$ 72.9	$ 88.6
Oceanographic Centers and Facilities	43.6	42.5	47.4
Ocean Drilling Program	31.4	32.0	35.0
TOTAL	$145.9	$147.4	$171.0

Table 5. R & D in DOD's Atmospheric Oceanic Sciences

	FY 1989 Actual	FY 1990 Estimates	FY 1991 Estimates
Atmospheric Sciences			
Army	$ 21.2	$ 17.2	$ 15.5
Navy	18.8	20.5	19.6
Air Force	35.3	32.5	33.8
Subtotal	75.3	70.2	68.9
Oceanic Sciences			
Navy	89.3	88.1	96.9

Table 6. The National Oceanic and Atmospheric Administration

	FY 1989 Actual obl	FY 1990 Estimates obl	FY 1991 Estimates obl
National Ocean Service	$121.1	$140.6	$139.5
National Marine Fisheries	161.8	197.3	153.2
Oceanic & Atmospheric Research	157.0	173.1	199.5
National Weather Service	316.4	445.3	470.0
NESDIS	383.6	264.5	280.4
Program Support	127.4	137.0	149.3
TOTAL	$1,267.3	$1,357.8	$1,391.9

Chapter 15

Earth Sciences in the FY 1991 Budget

American Geological Institute

Marvin E. Kauffman, Nicholas H. Claudy

Research and development funding for FY 1991 Budget again shows moderate increases. Funding problems continue for many federal agencies as they plan research and development activities. Agencies unable to provide information for this report will again be contacted for next year's publication together with those listed below.

U.S. DEPARTMENT OF AGRICULTURE; AGRICULTURAL RESEARCH SERVICE

The Agricultural Research Service provides research support for the action agencies of the Department of Agriculture. The Agency also undertakes research directed toward the development of technologies that improve the efficiency of food and fiber production. The primary goal of the Agency's Natural Resources Research Program is to develop the means for managing and conserving the nation's soil and water resources for a stable and productive agriculture.

In FY 1990, the funding of earth sciences research has been increased by $8.0 million. These funds will be used to accelerate the development of economically viable solutions to water quality problems resulting from agricultural activities. The research to be undertaken with these added resources is part of a major national effort to develop and promote the use of technologies that minimize the adverse effects of agricultural chemicals on the quality of the Nation's water resources. Most of the work will directly support the 1990 Presidential initiative on water quality, and will be conducted in collaboration with a number of federal and state agencies, and state universities. Emphasis is being given to the solution of groundwater quality problems associated with corn and soybean production in the Midwest.

In FY 1991, the Agency's budget request includes $7.4 million for expanding the work on water quality to other major crop producing areas, and for accelerating research to fill major gaps in scientific knowledge and data bases related to water quality management. The budget also includes $7.4 million for research related to documented changes in atmospheric constituents and projected changes in global climate. Planned research will include more detailed investigations of nitrogen and carbon cycles, evaluations of the effects of agricultural production practices on the environment, and an assessment of the effect of increases in carbon diozide concentration on agricultural productivity. Total funding for earth sciences research in the Agency is close to $80 million for FY 1991.

FOREST SERVICE

The USDA-Forest Service research and development program in the geosciences is focused on water quality, water quantity, and soil protection.

Water quality research goals are to identify forest management activities that adversely affect the various uses of water in streams and lakes, to identify environmentally safe alternatives, and ~~to~~ develop mitigating practices. An additional goal is to assess the impacts of airborne pollutants such as atmospheric deposition of lakes and streams.

- Control of pollution from non-point sources will continue to be a major concern in forestry.

- The cumulative effects of management will only become evident over extended periods approximating the rotation age of timber stands. Long-term studies linking the effects of management on small watersheds to effects on whole drainages will be needed.

- Pollutants originating outside of the National Forests, such as atmospheric deposition, will continue to threaten water quality and an assessment of each pollutant will be necessary.

- Techniques for monitoring the health of forest ecosystems are needed.

Water quantity research goals are to identify forest management activities that alter the amount and timing of flow.

- In the arid West, water supply is seen as the life-blood to an expanding economy but several areas are now experiencing intermittent shortages that can only become more acute with time.

- Timber harvesting can also contribute to flooding by altering the timing of flow. We need to improve our understanding of rain-on-snow events, and of regional effects of stand conversion to avoid aggravating flooding conditions.

- The prospect of global climate change has been noted recently, and there is very little knowledge on the direct and indirect effects on forest hydrology. Significant changes could lead to long-term problems. Long-term ecosystem studies will be needed to evaluate this potential threat.

Soil Protection research goals are to provide more effective prediction of mass wasting hazards, and improve techniques for stabilizing disturbed watersheds.

- Forest plans are required to estimate the amount of erosion and subsequent loss of on-site productivity associated with each forest management activity.

Funding for FY 1991 has been requested at (in millions) $7.5 for water quality, $1.4 for water quantity, and $3.3 for soil protection (compared with $7.1, $1.4 and $4.3 respectively for 1990).

NATIONAL SCIENCE FOUNDATION

The National Science Foundation was established to promote and advance the progress of science in the United States, primarily by providing support for basic scientific and engineering research and by supporting activities in science and engineering education.

Research in Earth Sciences is supported primarily through programs in the Division of Earth Sciences, however significant support is also provided by the Marine Geology & Geophysics Program and the Ocean Drilling Program in the Division of Ocean Sciences, and by the Polar Geology and the Glaciology Programs in the Division of Polar Programs. In addition, some support is provided for Earth Sciences research through NSF's Division of International Programs, the NSF Graduate Fellowship Program, and through resources provided by the Division of Advanced Scientific Computing.

NSF's FY 1991 request includes $71.5 million for the Division of Earth Sciences, $35.0 million for the Ocean Drilling Program, $17.0 million for Marine Geology & Geophysics, and $12.0 million for Glaciology and Polar Earth Sciences support. Earth Sciences support from all other NSF Programs is estimated at $4.1 million in FY 1991. Thus the total requested support for Earth Sciences research is estimated to be $139.6 million. The equivalent support in FY 1990 is $123.1 million.

U.S. NUCLEAR REGULATORY COMMISSION; OFFICE OF NUCLEAR REGULATORY RESEARCH

The primary goal of the NRC seismic research program is to be able to define the potential for earthquakes at nuclear power plant sites and in the regions around the sites and to determine the possible effects earthquakes would have on the plants and their safety systems. Earth science research represents a major part of this program.

A major focus of the NRC research programs in geology, seismology, and geophysics continues to be identifying and defining potential earthquake sources or source zones in the Eastern and Central United States and using that information in assessing seismic hazards with respect to nuclear power plants. Many unknowns exist regarding these issues, including a strong basis for seismic zonation, source mechanisms, characteristics of ground motions, and site-specific response. The NRC is addressing these uncertainties through research that encompasses sustained seismic monitoring, geologic and tectonic studies, neotectonic investigations, exploring the earth's crust at hypo-central depths, and conducting ground motion studies.

The budget for NRC Earth Science Research has been $3.3 million (FY 1989), $3.25 (FY 1990), and $3.3 (FY 1991).

The budget for FY 1992 and beyond is expected to decrease due to the replacement of NRC-funded seismic stations by United States Geological Survey (USGS) operated seismographic network.

BUREAU OF LAND MANAGEMENT (BLM)

In the 1980s, the Bureau of Land Management's (BLM) research and development (R&D) program supplemented its earlier cooperative projects (with other federal agencies and established academic institutions) by adding several new initiatives.

The BLM initiated development of technology involving a computer-based fire management support system known as the Initial Attack Management System (IAMS) that provides an effective means of both short- and long-range fire and resource planning. In addition, BLM was a major participant in the Forestry Intensified Research (FIR) program, conducted jointly with the U.S. Forest Service and Oregon State University, which focused on forest management issues in southwestern Oregon.

In cooperation with the U.S. Forest Service and Oregon State University, BLM initiated a second major R&D effort directed at improving natural resources on lands in coastal Oregon. This effort, referred to as the Coastal Oregon Productivity Enhancement (COPE) Project, focuses on developing ways to restore and enhance forests and other renewable resources in the vicinity of the Oregon Coast Range.

In 1988, the BLM initiated the Greenstripping Project in Idaho. A major objective of this project is to develop and establish new varieties of grasses, shrubs, and other vegetation that remain green well into the hot, dry summer fire season. A second objective of the Greenstripping Project is to develop shrubs and vegetation that can resprout or re-establish naturally following repeat burning by wildfire, that can compete with undesirable vegetation such as annual grasses like cheatgrass, and which are also palatable to livestock and wildlife. This project, expected to cost $350,000 annually by FY 1991, is being carried out in cooperation with the U.S. Forest Service and the University of Idaho.

During the decade of the 1980s, the magnitude of BLM-funded R&D has ranged from $3,000,000 to $3,900,000 annually.

In the coming decade BLM, in cooperation with other federal and state agencies, will be addressing a variety of traditional and new R&D needs: a major federal research program to gain understanding of our changing global environment to be able to better predict and plan for changing conditions that may significantly affect the management of resources on the Public Lands; and a second research effort may be initiated to be directed at understanding the best ways to mitigate or adapt to a changing global climate likely to cause major biological change and disruptions in environmentally stressed ecosystems managed by the BLM in the western U.S. and in Alaska.

The BLM is also concerned about declining biological diversity in many areas of the Public Land and is planning research efforts for the 1990s to gain insights into ways to slow and reverse the current decline of diversity. Among the initial projects on this topic is a cooperative effort by BLM, academic institutions, and other agencies in the northern Great Basin to initiate a research program directed at finding ways to restore vegetation diversity and to remove and prevent future re-establishment of exotic weed monocultures in the northern Great Basin.

During the 1990s the BLM will also be addressing research needs associated with energy and mineral resource development, renewable resource uses, human impacts on natural resources, engineering and atmospheric science, improved grazing practices, destruction of rangelands by fire, and forest productivity enhancement. Continued research directed toward improving management of riparian and wetland habitats is also anticipated.

DEPARTMENT OF ENERGY

The goal of the geoscience research and development (R&D) in DOE's Office of Fossil Energy is the development and application of reservoir characterization data and related earth science information to aid in the location and production of domestic hydrocarbon resources (especially oil and gas). It is recognized that improved geoscientific data can enhance the development and application of conventional production methods to complex geologic formations. R&D is carried out primarily in three program areas. The Office of Technical Coordination requested $8.6 million for advanced extraction and process technology in FY 91. The Office of Oil, Gas, and Shale Technology requested $19.3 million for enhanced oil recovery, and $8.9 million was requested for unconventional gas recovery in FY 1991. The total FY 1991 request of $36.8 million compares to FY 1990 appropriations of $22.2 million.

The principal basic research efforts of the Department of Energy (DOE) in the earth sciences are funded in three programs of DOE's Office of Energy Research. The Geosciences Program of the Engineering and Geosciences Division has requested $17.5 million in FY 91 and emphasizes fundamental studies of the geochemistry and geophysics of rock-fluid systems in topical areas that underlie DOE's energy and defense missions. The Atmospheric and Climate Research Division ($79.2 million in FY 91) emphasizes scientific understanding of the effects of increasing the carbon dioxide and other trace gases and pollutants in the atmosphere in order to provide a sound basis for choosing appropriate policies to follow in the coming decades. The Ecological Research Division ($31.4 million in FY 91) emphasizes studies of the fate and effects of energy-related contaminants in the environment, with major emphasis on basic research for environmental restoration. The FY 1991 budget request for these programs totals $128.1 million, compared to FY 1990 appropriations of $108.5 million.

DOE's Office of Conservation and Renewable Energy, Geothermal Technology Division, Geothermal Research Program, investigates the origin, behavior, and productivity of geothermal systems. These systems include hot water and steam aquifers; overpressured saline aquifers; massive, hot impermeable rock; and subsurface molten rock masses. Applied geoscience research sponsored by the Program involves exploration, characterization, and energy extraction from geothermal systems. The $7.3 million requested by the Program in FY 1991 compares to an FY 1990 appropriation of $6.5 million.

DOE's Office of Civilian Radioactive Waste Management has the responsibility to conduct a program of site characterization for a geologic repository. Yucca Mountain, Nevada, has been designated by the Nuclear Waste Policy Act as Amended as the candidate for detailed site characterization activities to determine whether or not the site would be suitable for a repository for the permanent disposal of spent nuclear fuel and high-level radioactive waste. In order to characterize the Yucca Mountain site, a number of critical activities must be accomplished. These activities include geologic, hydrologic and geochemical studies. Field work will consist of drilling, trenching, water monitoring, seismic monitoring, and climate studies, An overall assessment of the potential for mineral, hydrocardon and geothermal resources will be initiated. Laboratory testing and analysis will be conducted on samples obtained from the field. The FY 1991 budget request for geoscience studies at the Yucca Mountain candidate site totals $42.5 million, compared to FY 1990 appropriations of $36.6 million.

U. S. GEOLOGICAL SURVEY

Research and development in the U.S. Geological Survey (USGS) supports three major programs areas:

Cartographic and geographic research focuses on the application of advancing technology to the mapping of the nation, using advanced information sources such as remote sensing from aircraft and satellites, improving hardware and software for digital processing and interpretation of source material; automated conversion of source material into map form; developing and improving digital production of maps; developing methods for management and dissemination of digital cartographic data application of geographic information systems to improved utilization and interpretation of geographic data in digital form.

Geologic and mineral resource surveys and mapping provides geologic, geochemical and geophysical information on mineral and energy resources, on solid-earth and marine processes, and on geologic hazards and their mitigation. Conducts basic and applied research in support of geologic hazards surveys (earthquake monitoring, volcano observatories, landslide research), geologic mapping and framework research (studies of the Earth's composition, structure, and history and of coastal erosion and wetlands), offshore geologic surveys (characterization of the seafloor and oceanic crustal processes), mineral surveys (resource assessments, ore deposit modeling, and techniques development), energy geologic surveys (oil and gas, coal, geothermal, and uranium), and global change research (paleoclimate, permafrost, desert processes, and glacier studies).

Water resources research focuses on advancement of the understanding of processes that influence the occurrence, movement, and interaction of water with the environment, both on the earth's surface and in the ground; investigation of the quantity and quality of the nation's water, development of better methods for managing, disseminating, and interpreting data concerning water quantity, quality, and use; improved understanding of the dissolution and transport of natural and man-made toxic and radioactive substances; and development of means for containing toxic and radioactive substances and reducing contamination of the natural environment and exposure of the populace to these substances.

The congressional budget enacted for the USGS for FY 1990 included R&D funding for $300 million; the Administration's budget for FY 1991 proposes R&D funding of $305 million. Highlights of the FY 1991 budget are:

- An increase of $14.5 million in Advanced Cartographic Systems with partially offsetting decreases in the National Mapping, Geography, and Survey activity.
- A net increase of $14.9 million in the Global Change Program with offsetting decreases in other programs in the FY 1991 budget.
- An increase of $11.0 million in National Water Quality Assessment program with offsetting decreases in other programs in Water Resources Investigations activity.

U.S. Geological Survey R&D Budgets (Total Dollars)

Fiscal Year	(millions)	Comment
1991	305	President's Request
1990	300	Estimate
1989	280	Actual
1988	236	Actual
1987	227	Actual
1986	219	Actual
1985	215	Actual
1984	210	Actual
Change in classification of budget items		
1983	157	Actual
1982	145	Actual
1981	162	
1980	144	

Chapter 16

Water Resources Research in the FY 1991 Budget

Universities Council on Water Resources

Robert C. Stiefel

INTRODUCTION

Water-related research is included in some way in most of the cabinet-level departments and independent agencies in the federal government, but this effort at examining the budget for water resources research is limited to the five departments and agencies having a major responsibility for the resource. In the author's opinion these agencies account for over ninety-five percent of the federal expenditures for water resources research. Water research in the marine environment and in the atmosphere is not considered, but is included in the Disciplinary Analysis on Atmospheric and Oceanic Sciences.

Funding for water resources research in the federal FY 1991 budget that is considered in this analysis amounts to $566.0 million. This is an increase of approximately 16 percent of the amount budgeted in FY 1990. Most of the increase can be attributed to the governmentwide water quality program and to the U.S. Global Change Research Program (USGCRP).

DEPARTMENT OF THE INTERIOR

The United States took a major step in FY 1990 to improve the quality of the policy decisions made in response to global environmental trends by establishing the U.S. Global Change Research Program. The Department of the Interior is actively involved in these policy and research issues, and is requesting $43.7 million in FY 1991 for its component. Four of the bureaus (GS, MMS, BOR, and FWS) are participating in water-related research in this program.

The Geological Survey (+$15 million) will be performing global change research in their mapping, geology and water resources divisions. In the water resources area, work will focus on how climate variability and change would affect hydrologic processes and on the development of methods to evaluate the sensitivity of surface and ground water systems to changing climatic conditions.

The Minerals Management Service (+$3.6 million) will examine existing long-term data bases of hydrographic properties in the Gulf of Mexico and monitor properties and indicators of air-sea interaction to detect climatic change.

The Bureau of Reclamation (+$2.4 million) will study the potential effects of global climate change on watersheds in the Western United States; and the Fish and Wildlife Service (+$3.6 million) will assess the possible impacts of climate change on species and habitats.

Geological Survey

The budget for Water Resources Investigations in FY 1991 is $155.7 million. Included in the request is an increase of $11.1 million for the National Water Quality Assessment (NAWQA) which is part of the President's Water Quality initiative. The objective of the program is to describe the status and trends in the quality of the Nation's surface and ground water resources and to provide a sound, scientific understanding of the primary natural and human factors affecting these conditions. In 1991, the NAWQA program will begin a multi-year transition from a pilot program status to a full scale national program.

A net increase of $4.2 million for the Global Change Research Program will expand research on how hydrologic processes affect climate variability.

Funding for the National Water Resources Research and Informations System federal program, the federal/state cooperative program, the Water Resources Research Institutes, and the National Water Resources Research Grants are being continued but at greatly reduced levels to partially offset these proposed changes.

Bureau of Reclamation

Within the Bureau's Construction Program, water technology and environmental research, including global climate change research, is funded at $13.3 million; while the request for General Investigations, which are used to study water-related problems and evaluate alternative solutions, is funded at a level of $11.5 million.

Fish and Wildlife Service

As a participant in the Global Climate Change program, the Service is requesting $3.6 million in funds to assess the impacts of climate change on species and habitats and to study the effect of sea-level rise on coastal wetland systems. Additionally, an increase of $650 thousand is proposed for the full operation of most of the 41 cooperative research units at universities.

DEPARTMENT OF THE INTERIOR
(in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget
U. S. Geological Survey			
National Water Resources Research & Information System-			
Federal Program	$ 75.6	$ 81.3	$ 94.3
Federal/State Coop Program	55.9	59.8	56.1
State Research Institutes	10.8	10.8	5.3
Total	$145.3	$151.9	$155.7
Bureau of Reclamation			
General Investigations	$ –	$ 11.3	$ 11.5
Construction Program	–	11.7	13.3
Total	$ –	$ 23.0	$ 24.8
Fish & Wildlife Service			
Research and Development-			
Coop Research Units	$ 6.3	$ 6.5	$ 7.2
Fisheries Research	15.0	13.3	12.2
Total	$ 21.3	$ 19.8	$ 19.4

ENVIRONMENTAL PROTECTION AGENCY

The 1991 President's budget provides a total of $449.6 million for EPA's research and development program. This represents an increase of $25.1 million over the 1990 level. Internal shifts of $20.5 million from completed research activities (acid rain and hazardous waste research) increase the level of funding to $45.6 million for major research initiatives in 1991.

The major increases will enhance global climate change research, help implement the Clean Air Act legislation, support new media research needs and strengthen the Agency's long-term research capabilities.

Funds for Water Quality Research will be increased by $2.2 million to support wetlands preservation, to improve oil spill cleanup technologies, and to study the long-term environmental effects of oil spills.

Drinking Water Research will continue to develop methods to detect ground water contaminants, understand and predict their behavior, and assess cost-effective alternatives for cleaning up contaminated ground water. Additional funds (+$1.1 million) will be provided to conduct studies on drinking water contaminants.

Funds for Hazardous Waste Research will decrease by $2.6 million as a result of research completed for the Hazardous Waste Program and one-time funding initiatives provided in 1990. Research will continue at a reduced level for treatment methods and technologies for hazardous waste land disposal, predicting releases of hazardous wastes from underground storage tanks, and understanding how hazardous waste biodegrades and moves below ground. Research will be increased for new and improved methods to manage municipal solid waste.

Research funds for Energy/Acid Rain Research will decrease $17.9 million, reflecting the completion of acid rain research for the Final Assessment Report to Congress by the National Acid Precipitation Assessment Program. In 1991, acid rain research will focus on long-term monitoring, modeling and analysis of emission scenarios.

Funds for Multi-media Research (formerly Interdisciplinary Research) will increase $25.6 million to strengthen the Agency's long-term research program and to upgrade scientific research equipment.

ENVIRONMENTAL PROTECTION AGENCY
(in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget
Office of Research and Development			
Water Quality	$ 8.9	$ 9.8	$ 12.0
Drinking Water	11.2	11.7	12.8
Hazardous Waste	31.1	28.3	25.7
Multi-Media	30.8	65.9	92.0
Pesticides	2.3	1.2	4.0
Toxic Substances	28.0	28.0	29.9
Total	$ 112.3	$144.9	$ 176.4

DEPARTMENT OF AGRICULTURE

The FY 1991 USDA budget contains several initiatives related to water, including research, water quality, and global changes.

Research. In 1991 a major research initiative is proposed to be funded at a level of $100.0 million. Through the use of competitive grants, this program will apply advanced technologies to reach solutions for the most urgent problems facing farmers, ranchers and consumers of agricultural products. Funding for this initiative is proposed to increase by $50.0 million in each of the outyears.

Water Quality. An additional $52.2 million over the 1990 level of $155.0 million is proposed for the 1991 budget. The increase will be used to continue and expand the governmentwide water quality initiative. Nine USDA agencies will provide data collection and analysis, research, education and financial assistance. Much of the initiative will be targeted to nonpoint source pollution identified in plans developed by states under requirements of Section 319 of the Water Quality Act of 1987. The major objective of the USDA water quality initiative is to provide farmers, ranchers and other land managers with the information necessary to voluntarily adopt improved environmentally sound management practices which do not sacrifice profitability.

A $13.5 million increase is proposed for federal and university research programs. Work will continue at sites being developed in 1990 in support of a targeted program to develop improved management systems for farmers in the Midwest Corn Belt, where concentrated corn and soybean production involves widespread use of nitrogen and pesticides in connection with conservation tillage practices.

- Determine the extent and seriousness of potential agricultural contributions to nonpoint source pollution.
- Develop improved farm and ranch management practices to maintain and improve water quality without sacrificing profitability
- Improve the understanding of transport and deposit of agricultural chemicals in soils and water.
- Develop less costly ground water sampling techniques.

Global Change. A total increase of $26.2 million is proposed for USDA global change programs as part of a governmentwide research and data analysis program. Research funding is proposed for federal labs operated by ARS and the Forest Service and for competitive grants to universities to assure that a broad spectrum of expertise can be engaged in developing appropriate solutions to major issues identified in global change plans. Two major objectives will be pursued. First, there is a need to understand the potential contributions of various crop and livestock systems to global change and to develop improved systems that reduce those effects. Examples include new rice and livestock production systems that reduce methane emissions from those sources. This research will also provide inputs to improve the predictive capabilities of climate models developed by other agencies. The second focus of agricultural research is to assess the effects of global change on agriculture and develop means to overcome those challenges to profitable production.

In addition to the directed global change programs described above, a number of other USDA research and data collection programs provide significant related inputs into better understanding and addressing global change issues. Included are soil and water research and survey programs, and research which supports development of crop plants better able to withstand climate extremes. These important programs will be continued.

DEPARTMENT OF AGRICULTURE
(in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget
Water Quality Programs			
Agricultural Research	$ 30.7	$ 38.6	$ 53.4
Coop State Research	23.9	29.1	44.7
Economic Research	13.9	15.9	23.1
Soil Conservation	0.0	0.0	1.5
Total	$ 68.5	$ 83.6	$122.7

NATIONAL SCIENCE FOUNDATION

Water resources related research funded by the National Science Foundation is included in several subactivities within the Engineering and Geosciences Activities. The Biological and Critical Systems and the Chemical and Thermal Systems Programs in the Engineering Activity and the Global Geoscience Program in the Geoscience Activity, which is the focus of NSF's contribution to the U. S. Global Changes Research Program, are the areas primarily doing water resources-related research.

NATIONAL SCIENCE FOUNDATION
(in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget
Engineering Activity			
Program Element -			
Biological Critical Systems	$ 5.3	$ 5.6	$ 5.9
Chemical and Thermal Systems	8.8	8.6	9.2
Geoscience Activity	10.3	12.5	16.7
Global Bioscience	2.6	2.9	2.7
Total	$ 23.4	26.6	28.2

CORPS OF ENGINEERS - CIVIL WORKS

The Administration's budget for U.S. Army, Corps of Engineers - Civil Works research and development activities for FY 1991 is for $45 million, a $3 million increase over FY 1990 levels. The principal activities for the budget are considered to be General Investigations, which are more fundamental research efforts, and Construction, Operations and Maintenance Investigations which are applied research efforts. Water resources research is included in several research areas proposed in the Corps budget. These areas include: Materials; Coastal Engineering; Flood Control and Navigation; Environmental Quality; Water Resources Planning Studies; Surveying and Satellite Application; and Construction, Operations and Maintenance.

The total funds requested for these program areas amount to $38.8 million, and represent an increase of about $1.5 million over the FY 1990 budget.

CORPS OF ENGINEERS - CIVIL WORKS
(in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Budget
General Investigation			
Research Areas Materials	$ 2.9	$ 3.2	$ 3.2
Coastal Engineering	5.8	6.0	6.2
Flood Control and Navigation	4.4	4.4	4.5
Environmental Quality	1.9	2.1	2.2
Water Resources Planning Studies	1.5	1.8	2.2
Survey & Satellite Application	1.3	1.3	1.5
Construction, Operations and Maintenance	18.5	18.5	19.0
Total	$ 36.3	$ 37.3	$ 38.8

Chapter 17

FY 1991 R&D in the Biological Sciences

American Institute of Biological Sciences

Jennie Moehlmann

Overview

Research within the biological sciences spans a number of federal agencies, and the general trend for the FY 1991 budget shows modest to healthy increases for life science research. Biological research ranges from genome mapping projects, jointly conducted by NSF, DOE, USDA, and NIH, to modeling the response of various ecosystems to changing environmental conditions. Some of the highlights of the President's budget proposal include:

- Partial implementation of the $500 million National Research Initiative for Agriculture, Food, and the Environment
- An 80 percent increase in funds requested for the Human Genome Initiative
- Doubling the ecological systems and dynamics research budget within the Global Climate Research Program

US Department of Agriculture

A major research change within USDA for fiscal year 1991 is the National Initiative for Research on Agriculture, Food, and the Environment, implemented through the CSRS competitive grants program. USDA proposes $100 million for competitive grants to fund the first year of the initiative. Funding for competitive grants is proposed to increase by increments of $50 million in each of the next 8 years until the $500 million target is reached. The initiative reorganized last year's seven categories of competitive grants research into four: animal systems ($30 million); plant systems ($50 million, including $15 million earmarked for plant genome mapping); natural resources and the environment ($15 million); and nutrition, food quality, and health ($5 million).

In addition to the initiative, USDA supports over $1 billion in R&D related to agriculture and forestry, mainly through the Agricultural Research Service, the Cooperative State Research System, and the Forest Service.

Agricultural Research Service (ARS) Across-the-board increases for the four life science research programs within ARS are proposed in the USDA budget. Soil and Water Conservation Research increases a healthy 21 percent to $89 million. Much of this amount will be spent on USDA's participation in government-wide water quality and global change programs. Plant Science Research increases 6 percent to $229.8 million. Projects include the genome mapping program (jointly funded with the National Research Initiative), and strengthening the plant germplasm system. Research within Animal Sciences is up a modest 4 percent to $104.1 million. An increase of $12 million is also proposed for ARS's Human Nutrition Research, up 11 percent from 1990.

Cooperative State Research Service (CSRS) Despite doubling the competitive grants program through implementation of the National Research Initiative, the research budget for CSRS will increase only 2.2 percent. Substantial decreases are proposed for CSRS special research grants that focus on regional problems (down from $56.3 million to $25.6 million). Cooperative Forestry Research is also slated for a decrease, from $17.3 million to $13 million. Aquaculture Research Centers, funded at $3.7 million in 1990, are again scheduled for elimination. The Animal Health and Disease Risk program was absorbed into the research initiative.

Forest Service Research conducted by USDA's Forest Service is down slightly. Forest protection research is down $600,000 to $35.6 million, and resource analysis research declines over $2 million from current

US DEPARTMENT OF AGRICULTURE (dollars in millions)

	Actual 1989	Current Plan 1990	Proposed 1991
Agricultural Research Service			
Soil/Water Conservation Research	$ 65.9	$ 73.6	$ 89.0
Plant Science Research	213.5	216.6	229.8
Animal Science Research	94.2	99.8	104.1
Human Nutrition Research	107.5	110.1	122.0
Cooperative State Research Service			
Hatch Act	154.7	155.1	158.5
Cooperative Forestry Research	17.5	17.3	13.0
1890 Colleges and Tuskegee	24.3	25.0	26.2
Special Research Grants	61.7	56.3	25.6
Competitive Research Grants	39.7	42.5	100.0
Natural Resources and Environment			
Water Quality			5.6
Atmospheric and Climate Change			9.4
Nutrition, Food Quality, Health			
Optimal Nutrition and Safety			3.0
Quality Specifications			1.0
Packaging			1.0
Plant Systems			
Plant and Pest Interactions			17.0
Genome Mapping			15.0
Plant Development Biology			12.0
Energy and Metabolism			6.0
Animal Systems			
Cellular Growth and Development			8.0
Molecular Basis of Disease			14.0
Genetics and Reproduction			8.0
Animal Health and Disease Risk	5.5	5.4	0.0
Higher Education	7.6	8.7	6.0
Aquaculture	3.8	3.7	0.0
Forest Service			
Forest Protection Research	19.8	36.3	35.6
Resource Analysis Research	24.4	27.7	25.6
Forest Environmental Research	29.5	35.5	36.6

appropriations, to $25.6 million. Forest environmental research is up $1 million in the budget proposal, to total $36.6 million.

Department of the Interior

The Fish and Wildlife Service (FWS) research budget decreases $5.5 million to $51.2 million, due mainly to completion of the cooperative acidification study. Other FWS studies deemed low priority, such as contaminants research and endangered species research, will be reduced or delayed according to the budget proposal. In addition, FWS proposes again this year to discontinue publication of the Wildlife Review and the Fisheries Review (-$565,000).

Total funding for the Endangered Species programs will increase only $150,000 (0.5 percent) to $30.5 million. These programs were incorporated in the President's America the Beautiful initiative.

National Science Foundation

The FY 1991 budget request provided an overall increase of 14.4 percent for the National Science Foundation, the nation's primary agency for promoting basic nonmedical, nonmilitary research. The Biological, Behavioral, and Social Sciences Directorate (BBS) within NSF, which is 18 percent of the total NSF research budget, is proposed to increase 11.6 percent to $327.53 million. BBS supports research in cellular and molecular biology, behavioral and neural sciences, and environmental biology.

Strengthening the research base and improving academic equipment and facilities accounts for over 70 percent of NSF's budget request. Biological highlights within the $1.81 billion research budget include NSF's role in the plant genome mapping project (joining USDA, DOE, and NIH) and global change research (supporting basic research to understanding bioresponse to climate).

NSF's Antarctic program will increase 15 percent to $175 million in FY 1991. Research focusing on geophysics, long-term ecological effects, and ocean sciences increases $2 million to $19 million.

NATIONAL SCIENCE FOUNDATION -- BIOLOGICAL, BEHAVIORAL, AND SOCIAL SCIENCES (dollars in millions)

	Actual 1989	Current Plan 1990	Proposed 1991
Molecular Biosciences			
Biochemistry	$ 13.5	$ 13.8	$ 14.7
Biophysics	14.3	14.7	15.6
Genetics	18.9	19.5	21.7
Total	46.7	48.0	52.0
Cellular Biosciences			
Cell Biology	15.8	16.1	17.2
Cellular Biochemistry	12.0	12.2	13.6
Developmental Biology	13.9	14.3	15.9
Physiological Processes	13.9	14.7	16.3
Total	55.5	57.3	63.1
Biotic Systems and Resources			
Ecology	10.0	10.7	11.8
Ecosystem Studies	23.5	24.4	26.9
Systematic Biology	12.7	13.7	15.0
Population Biology and Physiological Ecology	10.5	11.3	12.4
Biological Research Resources	6.2	6.6	7.3
Total	62.8	66.7	73.4
Behavioral and Neural Sciences			
Anthropology	7.9	8.0	8.6
Language, Cognition and Social Behavior	9.6	9.6	10.3
Biological Basis of Behavior	11.3	12.0	13.0
Neuroscience	16.0	16.2	17.1
Total	44.8	45.8	49.1

Environmental Protection Agency

EPA's request for R&D activities totals $450 million. Increases are scheduled for the exploratory research grants program, the ecological monitoring and assessment program, research in support of global change, and new research for the President's proposed Clean Air Act. Program-related research increases will focus on oil-spill cleanup and assessment, wetlands, and biotechnology. Media-related research budgets regarding the biological sciences include:

- Multimedia Multimedia research within EPA received a 31 percent increase to total $111.4 million for 1991. Most of the funds ($94 million) are for EPA's new long-term research program to expand Exploratory Research Grants and ecological and health risk research.

- Air Quality An increase of $17.1 million is proposed for air quality research within EPA to total $94.9 million. $7.8 million of the increase is for implementation of the President's Clean Air Act legislation to evaluate how alternative fuels affect air quality, human health, and the environment.

- Water Quality Water quality research within EPA increases 8 percent, to $28.9 million. The increase is targeted at assisting states in developing effective wetlands protection programs, increasing research on the long-term environmental effects of oil spills, and boosting state efforts to protect and restore selected watersheds suffering from nonpoint source pollution.

- Pesticides Pesticide research is up 22 percent, totaling $15.4 million. Research will include development of methods for identifying and monitoring biological pesticide agents.

- Drinking Water Research on drinking water contaminants increases 5 percent to $22.8 million.

National Institutes of Health

NIH's budget request totals $7.93 billion for 1991, an increase of only 4.7 percent. Research project grants that support 20,439 projects in basic biomedical research constitute the bulk of NIH funds ($4.425 billion). Competing grants will total 5095, an increase of 462 from the current year. NIH highlights include:

- Human Genome Project - NIH's proposed budget for the Human Genome Project, a joint venture with the Department of Energy, increases 81 percent to $108 million. The project, intended to span 15 years, is to identify and map the entire complement of genetic material that determines human life.

- Research Training - Research training for predoctoral and postdoctoral biomedical science students is funded at $292 million. This will support 12,020 research trainees, an increase of 225.

- AIDS/HIV - AIDS research within NIH will increase 7.6 percent to $800.2 million. Of the more than 20,000 research project grants mentioned above, 852 are for AIDS research.

The NIH budget also proposes to give the NIH director the discretion to direct up to one percent of NIH appropriations to take advantage of important emerging research opportunities.

NASA

NASA's Life Science Program received a 53 percent increase in the President's 1991 proposal to total $163 million. Emphasis will be placed on researching the effects of long-term exposure to weightlessness and the development of biological flight experiments for use on the Space Shuttle and the Space Station. Each of the three categories within the Life Sciences Program will receive substantial increases: Human Space Flight and Systems Engineering is scheduled for $71 million (+ 74 percent); Space Biological Sciences will receive $32 million (+ 51 percent); and Research and Analysis increases to $60 million (+ 35 percent).

US Global Change Research Program (USGCRP)

The US Global Change Research Program, initiated by President Bush in 1989, will receive a 57 percent increase in funding its second year. Seven government agencies will share $1.034 billion for research activities associated with global climate change. Much of the research will focus on ecosystem responses to changing climatic conditions. Agency research includes:

- EPA ($26 million). Climatic research within EPA includes modeling the consequences of climate change in sensitive areas such as tundra, wetlands and forests.
- USDA ($47.4 million). USDA research efforts include studies on climate effects on agricultural, forest, and range ecosystems.
- NOAA ($87 million). NOAA focuses its climate change research efforts on oceanic and atmospheric dynamics, biogeochemical dynamics, and a new initiative on the response of marine ecosystems.
- The Department of Energy ($66 million). DOE research includes vegetation and ecosystems responses to carbon dioxide increases.
- The Department of the Interior ($43.7). Research into ecological interactions with climate changes including arid, polar, and coastal regions and systems is part of DOI's global climate research projects. Environmental consequences, such as the loss of biodiversity, are also funded.
- NSF ($103 million). Several studies ranging from ocean circulation to database development are conducted within the National Science Foundation.
- NASA ($661 million). NASA research will focus primarily on three areas: climate response to the growth in the concentration of greenhouse gases, ocean and atmosphere interactions, and the role of oceans as depositories for carbon.

Department of Energy

DOE's Biological and Environmental Research (BER) program increases 8 percent to $339.2 million under the President's proposal. Projects under BER include the general life sciences program ($34.3) to support basic research into the cellular and molecular nature of living systems to understand the process by which DNA damage is repaired; database development ($73.1 million) for evaluation of health risks due to exposure to radiation and chemical agents; medical application research ($34 million) utilizing DOE's nuclear facilities; and the environmental research program ($44.7 million) to study the transport of discharges through the atmosphere, marine, and terrestrial ecosystems.

DOE's participation in the Human Genome Project will focus on developing technology to accelerate the mapping project by improving gene sequencing techniques, developing new instrumentation, and developing the necessary computer database. Funding for DOE's portion will reach $45.9 million, to bring the total amount of money requested for the project to $154 million.

Funding for DOE's Environmental Safety and Health program decreases 13 percent to $97.4 million in the request, due mainly to shifting nuclear oversight responsibilities to other programs.

National Oceanic and Atmospheric Administration

Within the Oceanic and Atmospheric Research budget, climate and air quality research increases 120 percent this year, totaling $118.7 million. Activities include studies on the behavior and effects of greenhouse compounds (ozone, carbon dioxide), atmospheric pollutants, and stratospheric ozone. Research within the Ocean and Great Lakes Programs, however, decreases 48 percent from the current appropriation to $39 million. A $14 million reduction in Sea Grants ($27.5 million proposed) and termination of the National Undersea Research Program (- $14.3 million) constitute most of the proposed reductions.

The total budget for NOAA's National Marine Fisheries Service is slated for a 22 percent decrease. Several research programs, including Antarctic and Chesapeake Bay studies, are proposed for elimination.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTATION (dollars in millions)

	Actual 1989	Current Plan 1990	Proposed 1990
National Ocean Service			
Observation & Assessment	$30.7	$41.9	$51.4
Ocean and Coastal Mgmt	43.7	47.3	41.2
National Marine Fisheries Service			
Information Collection and Analysis	101.2	104.2	98.2
Conservation and Management Operations	48.5	60.4	49.0
Oceanic and Atmoshperic Research			
Climate and Air Quality	46.3	53.9	118.7
Atmospheric Programs	40.0	43.8	41.8
Ocean & Great Lakes	70.4	74.9	39.0

Chapter 18

Chemistry in the FY 1991 Budget

American Chemical Society

Annette T. Rosenblum, Paul D. Graves

In the President's FY 1991 budget request, support for individual investigator research in academic chemistry departments continues to decline in real terms. Some growth is expected for chemistry in multidisciplinary areas targeted as priorities, such as global change, environmental waste, biotechnology, and materials science.

Highlights

- At NSF, programs traditionally supporting chemistry departments are slated to increase 5.5 percent.
- Support for chemistry at NIH barely keeps up with inflation, which is projected at 4.2 percent.
- DOD contract offices expect 0.8 percent growth for basic research in chemistry.
- Within DOE, chemistry funding is expected to drop 0.8 percent.
- In-house programs supporting chemistry at EPA increase 9.4 percent, while extramural research faces a decrease of 0.8 percent.

National Science Foundation

Programs supporting chemistry at the National Science Foundation would increase 8.1 percent overall. The FY 1991 request reflects the Foundation's continuing priorities of basic research, human resources, and infrastructure. Subprograms in the Chemistry Division increase 5.5 percent, or $5.4 million, above FY 1990.

- Within the Chemistry Division, two interdisciplinary initiatives--Materials Chemistry and Chemical Processing, and Chemistry of Life Processes--are targeted for an increase of $1.2 million to fund additional collaborative research in areas such as superconductivity, advanced materials for information technologies, membrane chemistry, and man-made enzymes. The bulk of the increase comes from established research activities.

- Emphasis on human resources in the Chemistry Division will translate into $2.1 million for graduate student research assistants and $1.7 million for 20 new investigators. Additionally, the Special Projects Office will increase $0.9 million for grants under the Research Experiences for Undergraduates (REU) program and for course and curriculum improvement.

Programs supporting chemistry in the Materials Research Division are slated to increase 6.2 percent to $81.2 million. The average size of grants awarded by the Division is projected to remain at the FY 1990 level, while the number of applications is expected to rise.

- Funding increases $3.1 million for research in biomolecular materials, and synthesis and processing of advanced materials. Funding for high-temperature superconductivity research will remain level, at $17.3 million. An addition of $2.4 million supports the establishment of one additional Materials Research Group, for a total of 18 groups. Development of the Minority Research Center of Excellence at Howard University will be funded at $1.0 million. Research at the center focuses mainly on electronic and opto-electronic materials.

Within the Geosciences Directorate, funding for the Global Geosciences program increases 34 percent, to $84.9 million. Research within this program will focus on atmospheric chemistry and biogeochemical cycles, as well as the earth's climatic and geological history.

- The Atmospheric Sciences Division rises $12.0 million for the Global Geosciences program, including support for atmospheric chemistry through the ongoing Global Tropospheric Chemistry program.

- Within the Earth Sciences Division, geochemistry research is slated to rise 30.0 percent over FY 1990 levels, in part for the Global Geosciences program. Areas of research supported include theoretical heterogeneous reactions occurring at the interface between the earth's molten metallic core and its crystalline oxide mantle, and the maturation of hydrocarbons in sedimentary basins.

National Institutes of Health

Funding for R&D at the National Institutes of Health increases 4.8 percent to $7.6 billion in FY 1990. Support for university departments of chemistry comes primarily

Table 2. Programs Supporting Chemistry at the National Institutes of Health*
(budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change FY90/91
NCI AIDS	$124.1	$150.3	$160.8	6.9%
NCI NON-AIDS	1,448.8	1,484.0	1,533.3	3.3%
• CPC	169.7	169.9	177.3	4.4%
NIGMS AIDS	10.9	14.6	15.5	6.2%
NIGMS NON-AIDS	673.0	697.4	730.0	4.7%
• CMBD	189.8	193.9	204.6	5.5%
• PS	92.5	99.2	103.5	4.3%

* Includes construction funds
Source: NIH

from the National Cancer Institute (NCI) and the National Institute of General Medical Sciences (NIGMS). Funding at these two institutes is expected to increase 4.0 percent. Based on this increase, support for chemistry (excluding biochemistry) at NIH also will rise 4.0 percent over FY 1990.

Increases of $63.3 million and $33.5 million in NCI and NIGMS, respectively (excluding construction), will be used to increase the number of competing grants. Most other extramural mechanisms continue to be funded at FY 1990 levels. However, within NIGMS, minority programs are increased.

AIDS research at NIGMS is examining the use of chemical techniques for rational drug design to develop therapeutic agents. NCI continues to fund drug design and synthesis under its AIDS and Treatment Research programs.

The proposed $49.3 million increase for NCI's Chemical and Physical Carcinogenesis (CPC) program will be used in part to continue to study the mechanism of action of heterocyclic amines as mutagens. Within NIGMS, the Cellular and Molecular Basis of Disease (CMBD) program is slated to increase 5.5 percent to support research examining the role new biochemical messengers play in the delivery of chemical substances to cells and body tissues. The Pharmacological Sciences (PS) program (up $4.3 million) will emphasize the molecular structures of immunosuppressants, the synthesis of new anti-viral agents, the molecular basis of anesthetic reactions in humans, and the design of new drug delivery systems.

Department of Defense

Overall support for basic research ("6.1" category in DOD's Research, Development, Test, and Evaluation program) is expected to increase 5.9 percent to $977.8 million. At this time, it is estimated that funding through the service contract offices--Army and Air Force--will share in this increase, whereas Navy research is expected to decline. Additional funding comes each year from other programs within the contract offices, as well as from other DOD accounts, such as the University Research Initiative (up 2.8 percent), In-House Laboratories, and the Strategic Defense Initiative (chart next page).

In FY 1991, research emphasis continues for the Navy in the chemistry of materials and chemical processes, and for the Air Force in biotechnology and nonlinear optical polymers.

Department of Energy

In FY 1991, Energy R&D in the Department of Energy is expected to decline 3.3 percent, while DOE Defense R&D is up 4.4 percent, and DOE General Science R&D increases 16.0 percent. In contrast, within Energy R&D, programs that support chemistry in Basic Energy Sciences and in Biological and Environmental Research increase less than inflation, up 2.0 percent to $194.6 million. Chemical research funded through the technology base programs--Biofuels Energy Technology, Energy Storage Systems, Energy Conversion and Utilization Technologies, and Fossil Energy--will decline 10.2 percent to $51.9 million. The University Research Instrumentation program remains constant.

Chemical Sciences and Materials Sciences Programs

The substantial increases proposed for programs under Chemical Sciences and Materials Sciences (MS) are destined for Facilities Operations, up 26 percent (to $54.5 million), and 45 percent (to $80.4 million), respectively. These increases pay for user facilities support, R&D on components for two new synchrotron facilities in MS, improvements at the High Flux Isotope and High Flux Beam

Table 3. Support of Extramural "6.1" Basic Research in Chemistry at Department of Defense Contract Offices
(budget authority in millions)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change FY 1990/91
Army	$ 5.5	$ 4.8	$ 5.1*	6.0%
Navy	15.6	16.5	15.6	-5.5%
Air Force	15.6	15.1	16.0*	6.0%
Total Programs Funding Chemistry	$36.7	$36.4	$36.7	0.8%

* Projected
Source: DOD Contract Offices

Table 1. Programs Supporting Chemistry at the National Science Foundation
(budget authority in thousands)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change FY 90/91
Chemistry				
Analytical & Surface	$12,720	$12,950	$13,660	-4.4%
Inorganic, Bioinorganic & Organometallic	15,960	16,250	17,170	5.7%
Organic & Macromolecular	23,880	24,520	25,290	3.1%
Physical Chemistry	28,460	29,060	30,480	4.9%
Special Projects	7,480	7,060	7,950	12.6%
Chemical Instrumentation	8,250	8,100	8,800	8.6%
Materials Research				
Solid State Chemistry	8,870	9,020	9,450	4.8%
Other Directorates				
Molecular Biochemistry	13,480	13,840	14,690	6.1%
Atmospheric Chemistry	8,600	10,000	12,000	20.0%
NCAR Atmospheric Chemistry	3,320	3,410	3,760	10.3%
Chemical Oceanography	14,090	13,900	15,300	10.1%
Subtotal, Programs Supporting Chemistry	$145,110	$148,110	$158,550	7.1%

Table 1. Continued.

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	%Change FY 90/91
Materials Research				
Polymers	$8,150	$8,000	$8,430	5.4%
Ceramic & Electronic Materials	8,330	8,530	9,010	5.6%
Instrumentation for Materials Research	3,950	3,950	4,300	8.9%
Materials Research Labs	26,070	26,300	28,150	7.0%
National Facilities	12,080	12,380	13,100	5.8%
Materials Research Groups	8,150	8,250	8,750	6.1%
Other Directorates				
Geochemistry *	$12,300*	$11,700*	$15,210*	30.0%
Subtotal, Programs Involving Some Chemistry	$79,030	$79,110	$86,950	9.9%
TOTAL, ALL PROGRAMS INVOLVING CHEMISTRY	$224,140	$227,220	$245,500	8.1%

* Estimate. Includes geochemistry in the Experimental and Theoretical Geochemistry, Petrogenesis and Mineral Resources, Surficial Processes, and Volcanology and Mantle Processes programs.

Source: National Science Foundation

Table 4. Programs Supporting Chemistry at the Department of Energy
(budget authority in thousands)

	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change FY 1990/91
BASIC ENERGY SCIENCES (BES) PROGRAM				
Chemical Sciences Research	$84,105	$97,137	$95,987	-1.2%
Materials Chemistry Research	17,538	18,151	18,828	3.7%
Energy Biosciences Research	20,374	20,674	20,200	-2.3%
Geochemistry Research	5,900	5,500	5,200	-5.5%
Subtotal	$127,917	$141,462	$140,215	-0.9%
OTHER PROGRAMS				
Biofuels Energy Technology**	$8,555	$10,650	$22,800	114.1%
Biological and Environmental Research**	46,143	49,314	54,349	10.2%
Energy Conversion and Utilization Technologies**	6,630	8,134	6,645	-18.3%
Energy Storage Systems**	11,486	11,621	12,189	4.9%
Fossil Energy - Chemistry	22,200	27,400	10,300	-62.4%
University Research Instrumentation	4,938	4,930	4,924	-0.1%
TOTAL, PROGRAMS INVOLVING SOME CHEMISTRY - OPERATING EXPENSES	$227,869	$253,511	$251,422	-0.8%

** Includes subelements funding some chemistry.

Source: Department of Energy

Reactors, as well as heavy water and enriched uranium for the two reactors (the latter costs are included for the first time in BES).

In contrast, the Chemical Sciences Research budget is down 1.0 percent to $96.0 million, affecting research across the board. Similarly, Materials Sciences Research receives a 1.0 percent reduction to $141.5 million, which includes preconstruction R&D for the Advanced Neutron Source facility. Both Research budgets are expected to have assessments for designated support as occurred in FY 1990.

Other Energy Programs

- Of the $10.3 million slated for chemical research support under Fossil Energy R&D, 10.7 percent (or $1.1 million) is estimated to wind up in academic institutions, a decrease of $1.4 million from FY 1990.

- Within Geosciences and Engineering, the $5.2 million expected for geochemistry would be used to emphasize rock/fluid interactions.

- Under Conservation, materials-oriented subprograms in Energy Conversion and Utilization Technologies are reduced, some below FY 1989 levels. Construction of Phase II of the Combustion Research Facility at Sandia will continue with the $4.0 million provided.

- Increases in Biofuels Energy Technology subprograms will support efforts to achieve technical and economic competitiveness for methanol and ethanol technology.

- Under the new Environmental Restoration and Waste Management account, it is too early to determine the involvement of chemistry research in the Technology Development program. However, $5.2 million is planned to design a fundamental research facility to advance molecular science and to apply the results to environmental problems.

Environmental Protection Agency

The Environmental Protection Agency is a regulatory unit of the government, and as such, the ultimate purpose of its research program is to support the agency's regulation of air and water quality, hazardous waste management, pesticides, toxic substances, and radiation. The overall FY 1991 budget request for EPA R&D is 10.5 percent above the FY 1990 appropriation.

Owing to the regulatory nature of EPA's mission, almost all R&D activities entail some form of chemical support. Since EPA funding is divided by program function rather than by discipline, this report discusses only those functions that appear to contain some chemical sciences activities.

- In the Monitoring Systems and Quality Assurance program, elements supporting chemistry would increase by 4.4 percent to $54.6 million. Funds for the development of innovative waste disposal and field monitoring technologies under the Superfund program rise by $0.2 million. Research to identify new methods for quantifying chemical compounds in the environment and their effects on humans grows by $0.1 million. Pesticides research, including microbial and biochemical pest control studies, would increase $0.1 million. Decreases in the hazardous waste program, including research on characterization of chemical compounds in solid wastes, total $1.5 million.

- The Environmental Engineering and Technology program decreases by 8.0 percent, with reductions totalling $6.7 million in extramural funds. Reductions include Superfund treatment technology research (down $8.3 million), and hazardous waste alternative treatment technology research (cut by $1.2 million). These reductions are partially offset by small increases. Indoor air quality and chemical exposure research is slated to increase by $0.9 million. Research on the impacts of processing and manufacturing new chemicals increases by $0.4 million.

- The Environmental Processes and Effects program shows an increase of 10.3 percent ($5.3 million) over FY 1990. Research and development of test methods for chemical, toxicological, and teratogenic properties of pesticides would grow by $1.5 million. Support for updating the gas chromatology and mass spectroscopy database of toxic pollutants in wastewater increases $0.4 million. Other proposed increases include $1.1 million for Superfund research on biodegradation, the characterization of in situ subsurface chemical and physical processes, and the evaluation of risk assessment procedures in hazardous waste.

- The Intermedia Research program is slated to receive a 30.6 percent increase in FY 1991. Of this, $22.7 million would support the development of a uniform risk assessment model for use by all EPA programs. Ecological risks, health risks, and risk reduction are to be factored into this effort.

- EPA's Acid Rain program is targeted for a 63.2 percent cut, losing $18.2 million. This large decrease reflects the completion of the National Acid Precipitation Advisory Panel's (NAPAP) assessment. Some funds would be allocated to other acid deposition programs at EPA.

Chapter 19

Behavioral and Social Research in the FY 1991 Budget

Federation of Behavioral, Psychological & Cognitive Sciences, Claudia Feller

American Psychological Association, Barbara J. Calkins

American Educational Research Association, Marcia Knutson

It is well documented that federal funding for research in the behavioral and social sciences has fluctuated markedly over the last 25 years. Federal support for most scientific research has increased substantially and with predictable regularity, while funding for the behavioral and social sciences, on the other hand, has fallen. Highlights of the FY 1991 budget proposal for these sciences follow.

Department of Health and Human Services (HHS)

The Administration's FY 1991 budget includes increases of approximately 3.5 percent for the programs that include much of the Department's behavioral and social science research. (See Table 1.) Exceptions include the drug research budget, which increases by 14.9 percent, and the AIDS budget, which increases by an average of 10 percent.

The National Institute of Mental Health (NIMH), housed along with the National Institute on Drug Abuse (NIDA) and the National Institute on Alcohol Abuse and Alcoholism (NIAAA) under the aegis of the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA), provides the lion's share of financial support for behavioral research on mental health and disability. Recommended for a 6.3 percent increase, behavioral research priorities at NIMH include the brain and behavior, child and adolescent mental disorders, Alzheimer's disease, suicide, the homeless mentally ill, rural mental health, and AIDS.

The total NIDA extramural research allocation increases significantly again this year, jumping by 14.9 percent. This represents continued federal support for research on

AIDS and intravenous drug abuse, along with NIDA's other priority areas: improving drug abuse treatment, maternal drug abuse and its effects on children, and prevention.

The NIAAA extramural allocation would increase only 4.6 percent in FY 1991. Focus will continue on the genetic/biological determinants of alcoholism, with new attention to environmental factors. This approach allows environmental, psychological, and genetic factors to be studied simultaneously. Other behaviorally oriented research topics include addiction, recidivism, tolerance development, treatment-patient matching, and the relationship between alcoholism and affective disorders such as depression, anxiety, panic, and suicidal behavior.

The National Institutes of Health (NIH) last year funded an estimated $258 million in health and behavior research, approximately 3.9 percent of its $6.6 billion budget. Most of NIH's research institutes support or conduct behavioral research, exploring behavioral and social factors in health promotion, disease prevention and treatment, and child development and aging processes. FY 1991 funding proposals for the programs that include this research range from slight reductions to a 4.4 percent increase.

Growth in the AIDS research budget has been overtaken this year by the growth in the NIDA budget. Still, increases were considerable, with $230 million of the $1.5 billion Administration's FY 1991 AIDS request targeted for ADAMHA, a significant share of which would be available for the support of psychosocial and behavioral research.

The Health Care Financing Administration will use its $36 million for research, demonstrations, and evaluation for priorities that include beneficiary awareness, preventive health care, quality of care issues, and long-term care. The Office of Human Development Services will use its funds for projects and activities in the areas of child abuse, early child development, youth substance abuse, and aging. The Agency for Health Care Policy and Research, created in December 1989 with the enactment of the Omnibus Budget Reconciliation Act of FY 1989, serves as the research arm of the Public Health Service principally responsible for medical effectiveness and patient outcome research, along with research studies to improve health care delivery methods and technology assessments.

Table 5. Programs Supporting Some Chemistry at the Environmental Protection Agency
(budget authority in millions)

		FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change FY 90/91
Monitoring Systems & Quality Assurance:	In-house	$18.0	$17.6	$19.0	8.0%
	Extramural	$34.9	$34.7	$35.6	2.6%
Subtotal		$52.9	$52.3	$54.6	4.4%
Environmental Engineering & Technology:	In-house	$16.8	$18.2	$19.5	7.1%
	Extramural	$54.4	$65.6	$57.6	-12.2%
Subtotal		$71.2	$83.8	$77.1	-8.0%
Environmental Processes & Effects:	In-house	$24.1	$24.1	$26.2	8.7%
	Extramural	$23.6	$27.3	$30.5	11.7%
Subtotal		$47.7	$51.4	$56.7	10.3%
Intermedia Research:	In-house	$9.4	$12.4	$15.8	27.4%
	Extramural	$34.1	$72.9	$95.6	31.1%
Subtotal		$43.5	$85.3	$111.4	30.6%
Acid Rain:	In-house	$3.5	$2.1	$0.9	-57.1%
	Extramural	$47.6	$26.7	$9.7	-63.7%
Subtotal		$51.1	$28.8	$10.6	-63.2%
ALL PROGRAMS INVOLVING SOME CHEMISTRY:	In-house	$71.8	$74.4	$81.4	9.4%
	Extramural	$194.6	$227.2	$229.0	0.8%
	TOTAL	$266.4	$301.6	$310.4	2.9%

Source: Environmental Protection Agency

Table 1. Department of Health & Human Services
(budget authority in millions)

	FY 1989 actual	FY 1990 estimate	FY 1991 budget	% change FY 1990-91
ALCOHOL, DRUG ABUSE & MENTAL HEALTH ADMINISTRATION				
Mental Health				
Extramural Research	$252.7	$304.7	$323.9	6.3
Drug Abuse				
Extramural Research	129.0	169.4	194.6	14.9
Alcohol Abuse				
Extramural Research	87.1	107.6	112.6	4.6
Treatment Outcome Research	2.3	7.8	8.3	6.4
NATIONAL INSTITUTES OF HEALTH				
Cancer				
Cancer Prevention & Control	78.8	79.8	80.5	0.8
Heart, Lung & Blood				
Heart & Vascular Diseases	579.9	581.3	603.2	3.8
Dental				
Oral Diseases & Disorder Research	94.2	96.3	99.1	2.9
Diabetes, Digestive & Kidney Disease				
Digestive Disease & Nutrition	113.2	117.5	122.1	3.9
Neurological Disorders & Stroke				
Biological Basis Research	252.9	258.9	270.3	4.4
Clinical Research	132.2	134.5	139.1	3.4
Child Health & Human Development				
Research for Mothers & Children	213.4	218.3	226.1	3.6
Population	120.0	122.8	127.2	3.5

Table 1. (continued) Department of Health & Human Services
(budget authority in millions)

	FY 1989 actual	FY 1990 estimate	FY 1991 budget	% change FY 1990-91
Eye				
Strabismus, Amblyopia & Visual Processing	39.7	39.7	41.3	4.0
Environmental Health				
Applied Toxicological Research	57.4	56.3	57.0	1.2
Aging				
Aging Research	185.5	196.6	203.3	3.4
Deafness & Communication Disorders				
Research	88.5	108.2	112.5	4.0
Nursing				
Research	26.0	29.5	30.6	3.7
OFFICE OF THE ASSISTANT SECRETARY FOR HEALTH				
AIDS	1,152.2	1,400.9	1,539.0	9.8
(ADAMHA)	(173.3)	(214.6)	(229.7)	7.0
(NIH)	(602.3)	(743.5)	(800.2)	7.6
(Centers for Disease Control)	(377.6)	(442.8)	(509.1)	15.0
HEALTH CARE FINANCING ADMINISTRATION				
Research, Demonstration, Evaluation	50.6	50.0	36.0	-28.0
OFFICE OF HUMAN DEVELOPMENT SERVICES				
Research, Training, Demonstration	31.3	36.3	43.3	19.3
AGENCY FOR HEALTH CARE POLICY & RESEARCH	---	---	39.1	---

National Science Foundation (NSF)

According to the 1988 National Research Council report entitled The Behavioral and Social Sciences: Achievements and Opportunities, NSF provides 25 percent of federal support for psychology and social sciences research on campuses and about 40 percent in the social sciences alone. Thus, changes in nature and level of NSF program support have a major effect on academic research in these areas.

Some of the best FY 1991 budget proposal news for scientists is from NSF, but the news is better for some than others. NSF requests an increase of 13.3 percent for research and related activities. The Biological, Behavioral and Social Sciences (BBS) Directorate would increase 11.6 percent (to $327.5 million). BBS has six divisions, two of particular interest to behavioral and social science researchers--Behavioral and Neural Sciences (BNS) and Social and Economic Science (SES). Less dramatic increases are proposed for these divisions: BNS, 7.0 percent; SES, 10.0 percent. Indeed, BNS and SES would receive $6.4 million of the proposed BBS $34.0 million increase.

Another BBS division, Instrumentation and Resources, is slated to receive a 12.4 percent increase. A small portion ($2.7 million) of the Instrumentation and Resources FY 1991 budget ($43.2 million) would be devoted to Studies in Science and Technology. This program includes study of ethical or value issues of current significance to United States science and engineering.

The Computer and Information Science and Engineering Directorate (+13.8 percent) has a division of interest to behavioral and social scientists--Information Robotics and Intelligent Systems (+14.5 percent). Research topics include formal models of information, knowledge, and reasoning; natural language processing; and cognitive systems, problem solving, and learning.

Congress provided the Science and Engineering Education Directorate (SEE) a large increase for FY 1990--19 percent. The FY 1991 proposal seeks an additional increase of 23 percent.

NSF budget proposal details of interest to behavioral and social scientists are found primarily in this chapter's Table 2. SEE information, however, is included in Table 3.

Department of Education

Although the Bush Administration's overall request for the Department of Education reflects a net increase of only 2 percent for FY 1991, research and statistics are the benefactors of a financial commitment made at the Education Summit "to provide research and development for programs that work, good information on the real performance of students, schools, and states, and assistance in replicating successful state and local initiatives all across the U.S."

The Department's Office of Educational Research and Improvement (OERI) has a primary role and responsibility in providing leadership in the area of education research. Traditionally its mission has been divided among basic research, statistics, and assessment. Most of OERI's funds would support ongoing activities: 10 regional labs; 19 research centers with additional centers yet to be announced; 16 Educational Resources Information Centers (ERIC); a field-initiated studies program; and data gathering activities at the National Center for Education Statistics, for which a 66 percent increase has been requested. Last year (after sequestration), the final appropriation for OERI was $95.2 million. When comparing the same programs for FY 1991, the Administration's request is $121.7 million (+$26.5 million or 27.8 percent).

This year, however, the President included four new initiatives under educational research: Evaluation of Reform, Dropout Prevention, Principal Training, and Education Summit Follow-up. Requested for these programs is $53 million, bringing the total request to $174.7 million (+83.8 percent). There is some disagreement between the Congress and the Administration as to whether these initiatives will require authorizing legislation. There is also some debate as to the qualification of these initiatives into a research agenda, although the Dropout Prevention program does specify a research center.

Significant increases were requested for research programs that correspond with the President's education goals—e.g., Adult Education Research, Development and Evaluation would go from $2 million to $8 million (+300 percent). Other Department research programs are scheduled for minimal or no increases except for the significant Women's Equity decrease. See Table 3 for details of educational R&D at the Department of Education as well as NSF.

Department of Defense (DOD)

DOD is a major supporter of behavioral and social science research, most of which is categorized as "human resources technologies"--manpower, personnel, training and human factors in systems. Increasingly, the emphasis is on the immediate questions and needs of the services.

This research, like all Defense R&D, is classified by type of effort (6.1, basic research; 6.2, exploratory development; 6.3, advanced development; and 6.4, prototype development). Most university-based behavioral scientists are interested in 6.1 and 6.2 research. The FY 1991 budget for manpower, personnel, training and human factors in systems for 6.1 research is $31.0 million, an increase from the current FY 1990 funding of $29.9 million. The proposed FY 1991 budget for 6.2 research is $90.6 million, up slightly from the $89.8 million of FY 1990.

FY 1991 funding proposed for the Air Force Office of Scientific Research (AFOSR) is $193 million, up from $182 million in FY 1990. Proposed funding for the Life Sciences Directorate at AFOSR would also go up--from $18.4 million in FY 1990 to $19.1 million in FY 1991.

At the U.S. Army Research Institute (ARI), the total budget for 6.1, 6.2 and 6.3A (advanced but no systems) would increase from $37.73 million in FY 1990 to $38.97 million in FY 1991. However, funding in ARI's Office of Basic Research would decrease from $3.578 million to $3.403 million.

Meanwhile back at the Navy, the Office of Naval Research (ONR) Cognitive and Neural Sciences Division (6.1) would go from $14.6 million in FY 1990 funds to an estimated $14.7 million in FY 1991 under the current proposal.

Other Programs

The Department of Agriculture's Agricultural Research Service, Cooperative State Research Service, Economic Research Service, and Forest Service all fund some behavioral and social science research; however, they are covered in other chapters and tables in this volume.

USDA's Agricultural Cooperative Service (ACS) helps farmers help themselves by providing the assistance necessary to support and improve existing cooperatives and organize new cooperatives. ACS provides technical assistance and conducts research on economic, financial, organizational, legal, social, and other related issues that affect cooperatives. The FY 1991 budget requests $4.8 million for ACS (+$0.1 million).

USDA's Office of Transportation (OT) analyzes the rural transportation system and represents rural interests regarding the needs for adequate facilities to transport people and agricultural commodities. OT conducts research on specific transportation problems and provides technical and administrative assistance and coordination in the development and implementation of agricultural transportation policies and programs of USDA. The FY 1991 budget requests $2.4 million for this agency, the same as FY 1990.

USDA's National Agricultural Statistics Service (NASS) collects and reports statistical data, but also conducts and coordinates research on statistical techniques. An increase of $14.3 million over the FY 1990 current estimate of $67.1 million is requested for NASS. The proposed increase includes $2.4 million to improve statistical sampling frames in order to enhance efficiency and quality of data collection, and $1.8 million to enhance data collection on agricultural labor and wage rates.

The Department of Commerce's Bureau of the Census has a small general research program that conducts research on survey methods and techniques to find ways of improving the efficiency, accuracy, and timeliness of statistical programs. General research funding in FY 1990 is $701,000; the FY 1991 budget proposal for this program is $749,000.

The Department of Justice's Office of Justice Programs include: 1) Research, evaluation, and demonstration programs to provide for and encourage the development of basic and applied research for the improvement of justice systems. FY 1990 funding is $22.8 million; funding proposed for FY 1991 is $24.5 million. 2) Juvenile justice programs to assist with more effective education, training, research, prevention, treatment, and rehabilitation. No new funds are requested for the traditional program--funded in FY 1990 at $69.4 million. Instead, $7.5 million is requested to continue a High Risk Youth program that addresses the problems with gangs and drugs. It is also proposed that grant recipients contribute a hard cash match of 50 percent of total project costs.

Chapter 20

Federal Statistics in the FY 1991 Budget

Council of Professional Associations on Federal Statistics

Katherine K. Wallman

Overview

Statistics produced by the federal government serve as a base for research in a broad spectrum of scientific disciplines. Population and vital statistics are central to the work of demographers and actuaries; employment, financial, and production data are essential for economists; and information on education and crime is used by sociologists and psychologists.

Researchers in the social sciences are not alone in their reliance on federal statistics. Epidemiologists and biostatisticians depend on data from the National Center for Health Statistics and the National Institutes of Health; meteorologists rely on information compiled by the National Oceanic and Atmospheric Administration; and scientists in an array of professions are concerned with statistics that are gathered and distributed by agencies such as the National Science Foundation, the Soil Conservation Service, the Environmental Protection Agency, and the Geological Survey.

Responsibility for the collection, analysis, and dissemination of federal statistics is spread throughout the departments and independent agencies of the executive branch; each of some 70 agencies and departmental units annually spends $500,000 or more on statistical activities. Within this decentralized system that generates statistical information, a more limited number of agencies have the creation of statistics as their principal mission. It is these agencies, which are responsible for producing statistics on major economic, demographic, and social developments and trends, that are the focus of discussion in this chapter.[1]

For FY 1991, budget levels that have been proposed for the principal statistical agencies generally would provide modest increases in funding.[2] These increases in most cases would cover mandatory rises in the costs of continuing ongoing activities, routine program maintenance, and variable costs associated with the conduct of periodic surveys implemented on a cyclical basis.

In addition, the budget for FY 1991 places special emphasis on initiating activities to strengthen economic statistics. Noting that "improved economic statistics will assist both business and government in making sound business and economic policy decisions," the President's budget for FY 1991 requests an increase of $52 million over FY 1990 funding levels for various economic statistics programs. As outlined in the February 1990 Economic Report of the President, the funding proposals contained in the FY 1991 budget reflect the initial phase of a multi-year initiative recommended by the Economic Policy Council and approved by the President. The near-term recommendations concentrate on "the most important steps required to maintain and improve the 'core' economic statistics in three major areas of policy concern: productivity, output, and prices; investment, saving, and wealth; and employment, income, and poverty." In the following sections, details on these and other FY 1991 proposals for activities of the principal statistical agencies are provided.

Bureau of the Census

The Bureau of the Census collects, compiles, and publishes general purpose statistics on the population and the economy. Budget authority for the Census Bureau is provided in two appropriations: one covers "current programs," including demographic surveys, international programs, and data on construction, manufacturing, retail and wholesale trade, services, foreign trade, and state and local government finances and employment; the other covers "periodic programs," including the decennial census of population and housing, intercensal estimates of population, and the quinquennial economic censuses, census of governments, and census of agriculture.[3] For FY 1991, the proposed $115.2 million level for the current programs budget provides an increase of $15.3 million over FY 1990, an amount that would permit certain improvements to service sector, trade, and demographic data. Increases in business statistics programs would fund improved methods to reduce non-sampling errors in the Advanced Retail Sales Survey; expansion of corporate financial data collection and annual detail for service industries; improved measurement of services purchased by industry and collection of small company financial data; and publication of data for specific growth industries as well as assignment of unique industrial classification codes to these emerging industries. Increased resources for manufacturing statistics would permit initiation of an annual survey to collect investment data from all business sectors as well as activities to improve the quality and quantity of responses to the Manufacturers' Shipments, Inventories, and Orders Survey. Increases proposed for general economic statistics would enable the Census Bureau to expand research related to the revision of the Standard Industrial Classification and to participate in the National Trade Data Bank program. In the area of foreign trade statistics, proposed increases would provide for a comprehensive program to assess and improve data quality. Increased resources for the Census Bureau's demographic surveys would support initial redesign and reprogramming of the Current Population Survey, and restoration of the Survey of Income and Program Participation sample to its optimal size, allowing the production of longitudinal data.

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[1] The publication date for this report precludes completion by other agencies of the analyses required to present budget data for their "statistical" activities.

[2] For details of the funding history in fiscal years 1989 through 1991, see the table at the end of this chapter.

Bureau of Labor Statistics

The Bureau of Labor Statistics collects, analyzes, and disseminates data on employment and unemployment; prices and living conditions; consumer expenditures;

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[3] See table for information concerning the proposed FY 1991 budget for Census periodic programs.

Table 2. National Science Foundation
(budget authority in millions)

	FY 1989 actual	FY 1990 estimate	FY 1991 budget	% change FY 1990-91
BIOLOGICAL, BEHAVIORAL & SOCIAL SCIENCES				
Behavioral & Neural Sciences				
Anthropology	$ 7.9	$ 8.0	$ 8.6	7.5
Language, Cognition & Social Behavior	9.6	9.6	10.3	7.3
Biological Basis of Behavior	11.3	12.0	13.0	8.6
Neuroscience	16.0	16.2	17.1	5.5
Social & Economic Science				
Economics	12.9	13.3	14.3	7.1
Geography	2.9	3.2	3.9	19.1
Sociology	3.7	4.0	4.3	9.6
Measurement Methods & Data Improvement	2.4	2.4	2.6	10.5
Political Science	3.8	3.9	4.2	9.8
Law & Social Sciences	1.9	2.1	2.4	14.1
Decision, Risk & Management Science	3.3	3.4	3.8	10.8
Instrumentation & Resources				
Instrumentation & Instrument Development	16.6	16.0	16.6	3.8
Special Projects	17.7	20.0	24.0	19.9
Studies in Science & Technology	2.3	2.5	2.7	7.7
COMPUTER & INFORMATION SCIENCE & ENGINEERING				
Information Robotics & Intelligent Systems				
Knowledge & Database Systems	7.7	7.8	9.1	17.7
Robotics & Machine Intelligence	6.0	6.2	6.6	5.0
Interactive Systems	2.7	2.7	3.1	14.7
Information Technology & Organizations	2.8	3.3	4.2	24.9

Table 3. Educational Research & Development
(budget authority in millions)

	FY 1989 actual	FY 1990 estimate	FY 1991 budget	% change FY 1990-91
DEPARTMENT OF EDUCATION				
OERI Research & Statistics	$ 78.2	$ 95.2	$174.7	83.5
(Research)	(47.1)	(55.4)	(61.3)	10.6
(Statistics)	(21.7)	(25.0)	(41.5)	66.0
(Assessment)	(9.3)	(14.8)	(18.9)	27.7
(Four New Initiatives)	---	---	(53.0)	---
Handicapped Innov. & Development	17.0	19.8	19.8*	0
Handicapped Spec. Studies	3.6	3.5	3.5*	0
National Institute on Disability & Rehabilitation Research	53.5	54.3	54.3	0
Voc. Educ. Res. & Data Systems	11.4	11.9	11.9*	0
Funds for Improv. Postsec. Educ. (FIPSE)	11.9	11.7	11.7	0
Women's Educational Equity	2.9	2.1	1.0	-52.4
Adult Educ. Research & Development	2.0	2.0	8.0	300.0
NATIONAL SCIENCE FOUNDATION				
Science & Engineering Education				
Research Career Development	31.0	36.9	44.9	21.7
Materials Development, Research & Informal Science Education	44.0	48.0	61.5	28.1
Teacher Preparation & Enhancement	63.7	81.0	89.6	10.6
Studies & Program Assessment	4.5	4.4	5.0	14.5
Undergraduate Science, Engineering & Mathematics Education	28.0	34.0	50.0	47.1

* current proposal not yet available

wages and employee benefits; industrial relations activities; productivity and technological change in U.S. industries; projections of economic growth, the labor force, and employment by industry and occupation; and occupational injuries and illnesses. For FY 1991, the proposed budget authority of $252.8 million, a rise of $11.4 million over the estimated level for 1990, would allow BLS to continue its highest priority programs and to initiate several immediate improvements in its employment, price, wage, and productivity data series, focusing on currently uncovered components of the service sector. Specific projects would include expansion of the Current Employment Statistics program to permit monthly publication of employment, hours, and earnings data for thirty-five additional service sector industries; expansion of the Producer Price Index program to begin to provide coverage of the health services industry, and of the International Price program to produce measures of price changes for ocean liner freight services; expansion of the Employment Cost Index program to provide separate measures of the change in employer labor costs for the nursing and personal care facilities industry; and an expansion of the Industry Productivity program to begin to extend coverage in areas such as financial services, insurance, wholesale trade, health services, and other personal or business services. In addition, an increment in the BLS budget for the Current Population Survey redesign would permit the conduct of activities related to questionnaire redesign, state sample expansion, and enhancement of longitudinal data. A requested increase for the Occupational Safety and Health Statistics program (funded by the Occupational Safety and Health Administration on a reimbursable basis) would permit BLS to begin developmental work on a Fatal Occupational Injury Data System. Also included in the proposed BLS budget for FY 1991 are resources to cover the one-time costs associated with consolidation of BLS staff in a single building site. In order to provide resources for continuing BLS series having the highest priority, the FY 1991 budget proposes to terminate the Mass Layoff Statistics program, a federal-state cooperative effort for which BLS has provided developmental funds since 1984.

Bureau of Economic Analysis

The Bureau of Economic Analysis prepares and interprets the United States national income and product (GNP) accounts, as well as the wealth accounts, input-output accounts, balance of payments and associated foreign investment accounts, personal income and related economic series, and measures relating to environmental change within the framework of the national economic accounts. For FY 1991, BEA's proposed budget authority would rise by $8.7 million over the FY 1990 level, to a total of $34.3 million. Increased funding for the national economic accounts would be used to stop deterioration of the present accounts and to undertake work necessary for the United States to move to a modernized and extended set of accounts in 1995. New or improved measures would be developed for consumer expenditures on services and output of service industries, prices of high-tech goods other than computers, detailed types of goods and services purchased by state and local governments, and activities of the nonprofit sector. The set of national accounts to be introduced in 1995 will be consistent with international guidelines in the upcoming revision of the United Nations' System of National Accounts, which will include full current and capital accounts and satellite accounts. Increased funding for the balance of payments and international investment estimates would be used to develop measures of the net international position of the United States at current values, measures of two types of international services, and more detailed state and industry information on foreign direct investment in the U.S., as well as to improve compliance with the reporting requirements of the BEA direct investment surveys.

Statistics of Income, Internal Revenue Service

The IRS Statistics of Income program provides annual income, financial, and tax data based on individual and corporate income tax returns; periodic studies based on returns such as those filed by estates and trusts; and in-depth analyses of various tax-related computations, including those reported for the foreign tax credit and sales of capital assets. For FY 1991, a total budget authority of $21.2 million is proposed for the SOI program, an amount that exceeds the FY 1990 estimate by $1.5 million. The increase in funding would be used primarily for ADP support modernization efforts, with a goal of achieving a distributed processing system to improve data quality and realize processing efficiencies. Because the resources needed to complete the modernization effort exceed the amount of the proposed budget increase, plans for several smaller SOI projects in the international and tax-exempt organization areas will be modified, and the corporation and individual tax return publications will be scaled back somewhat. On the other hand, publication of summary statistics based on the Taxpayer Usage Study will be resumed, and the revised design of the SOI sample of individual income tax returns will be fully implemented, resulting in new data for use in research by the Office of Tax Analysis.

National Agricultural Statistics Service

The National Agricultural Statistics Service collects and reports data on a wide range of agricultural characteristics, including crop and livestock production, inventories, prices paid and received by farmers, costs of production, farm labor usage and wage rates, and other agricultural economic indicators. For FY 1991, the proposed budget authority for NASS is $81.2 million, an increase of $14.3 million over FY 1990. Funding at this level would allow NASS to conduct a new survey of agricultural chemical use data in support of water quality and food safety initiatives; to improve sampling frames to increase efficiency of operations and the quality of statistical output; and to expand sample sizes for agricultural labor and wage rate surveys in order to publish state (rather than regional) estimates for this program.

Economic Research Service, USDA

The Economic Research Service performs agricultural economic and other social science research, outlook forecasting, and policy analysis, and develops economic and statistical indicators related to U.S. and international agriculture, food, natural resources, and rural America. For FY 1991, a funding level of $56.3 million is proposed for ERS, an increase of $5.6 million over FY 1990. The requested increase would be applied to the analysis of food safety issues and to the expansion of chemical data collection and water quality analysis.

Energy Information Administration

The Energy Information Administration collects, analyzes, and disseminates data on energy resources, production, distribution, consumption, technology, and related international, economic, and financial matters.

EIA produces reports with statistical time series, projections of future energy trends, and analyses of topical energy issues, and supports the information needs of the Department of Energy. EIA's proposed budget for FY 1991 is $66.6 million, an increase of $2.3 million over FY 1990. Funding at the proposed level essentially would allow the agency to maintain the National Energy Information System at its current level with only minor changes. For the energy end-use program, which includes four surveys conducted on a triennial basis, funding is requested for the Manufacturing Energy Consumption Survey, the Residential Transportation Energy Consumption Survey, and a sampling frame update for the Commercial Buildings Energy Consumption Survey planned for 1992. In FY 1991 (as in FY 1990) a significant portion of EIA's modeling and analysis agenda will be directed toward supporting the department's initiative to develop a National Energy Strategy.

National Center for Health Statistics

The National Center for Health Statistics produces information on the full spectrum of concerns in health from birth to death, including overall health status, lifestyle and exposure to unhealthful influences, the onset and diagnosis of illness and disability, and the use of health care and rehabilitation services. Data sources include the nation's vital statistics system and surveys involving personal interviews, physical examinations and laboratory testing, and information from health care providers. For FY 1991, the budget request includes $48.1 million for NCHS, a decrease of $0.4 million from FY 1990. The FY 1991 budget also proposes that as in FY 1990, $19.0 million in Public Health Service "evaluation funds" be made available to provide funding for NCHS activities. The decrease in overall funding proposed for NCHS programs in FY 1991, coupled with significant cost increases associated with continuing the Center's ongoing survey operations, will leave the agency with a considerable shortfall in the resources necessary to operate its data systems at planned levels. Several periodic surveys, including the National Survey of Family Growth, will be postponed at least one year. Further curtailments in the NCHS program also will be necessary. While no final decisions have yet been made, it appears that one of two strategies will be employed to accommodate the proposed level of resources. A major survey, such as the

National Health Interview Survey, could be eliminated for 1991. Implementation of this option would result in a considerable loss of data, but would permit the conduct of NCHS' remaining programs at or near planned levels in 1991 and 1992. Alternatively, NCHS could implement across-the-board reductions in all of its major activities, requiring cuts in each program. Implementation of this option would likely result in reductions in the Vital Statistics system (the marriage and divorce components, as well as other data items); a reduced sample size for the National Health Interview Survey; suspension of plans to conduct components of the National Health Care Survey; and the furlough of one of two field teams involved in the National Health and Nutrition Examination Survey, causing a slowdown in data availability.

National Center for Education Statistics

The National Center for Education Statistics collects, analyzes, and reports statistics on American education; conducts studies on international comparisons of education statistics; and provides leadership in developing and promoting the use of standardized terminology. For FY 1991, a budget authority of $60.4 million is proposed, an increase of $20.7 million over FY 1990. Of this total, $18.9 million would support the National Assessment of Educational Progress (NAEP); the balance would fund the Center's ongoing programs, as well as activities initiated pursuant to mandates of the Elementary and Secondary School Improvement Amendments of 1988. Resources for NAEP would fund analysis and reporting of data from the 1990 assessment and preparations for the 1992 assessment,which will include state-level assessments in mathematics and reading. In programs related to elementary and secondary education, the FY 1991 budget would support data collection and methodological studies for the Schools and Staffing Surveys; improvements in the comprehensiveness and comparability of the Common Core of Data; expansion of the National Cooperative Education Statistics System; field testing of the second follow-up for the National Education Longitudinal Study of the Eighth Grade Class of 1988; and the first full-scale data collection for the National Household Education Survey. At the postsecondary level, the proposed budget would support a Recent College Graduates Survey; two components of a new postsecondary longitudinal study, a Survey of Beginning Postsecondary Students and the fourth follow-up of the High School and Beyond cohort of students; and upgrading of the Integrated Postsecondary Education Data System. Two major international studies, a field test for the Adult Literacy Assessment, and the Census Mapping project also would be funded.

Bureau of Justice Statistics

The Bureau of Justice Statistics is responsible for collecting, analyzing, and disseminating information on crime, victims of crime, criminal offenders, and operations of justice systems at all levels of government. For FY 1991, the proposed budget authority is $23.1 million, an increase of $2.2 million over FY 1990. The requested funding level includes an increase to establish a comprehensive statistical series addressing the relationship of drugs, guns, and violent crime. Information to be collected would explore the relationship of drug use to crime and the use of firearms during the commission of crimes; track drug offenders from arrest through court disposition; examine criminal histories of drug offenders; and inform a full range of drug policy issues related to law enforcement resources. The FY 1991 request also includes funding to continue implementation of the National Crime Survey Redesign and to expand the Federal Integrated Data Base, a system that links data from various units within the Department of Justice to track offenders through the federal system.

Office of Policy Development and Research, HUD

The Office of Policy Development and Research at the Department of Housing and Urban Development maintains data series on national, regional and local economic and housing market conditions. These include information on the physical and financial characteristics of national and selected metropolitan housing inventories and the characteristics of occupants; housing units under construction and completed; new one-family home sales; market absorption of new rental apartments and condominiums; the placement of new mobile homes; and mortgage lending and commitment activity. For FY 1991, a funding level of $14.7 million for the housing and financial market statistical programs is proposed, an increase of $1.7 million over FY 1990. Funds to support in part the post-censal Residential Finance and Components of Inventory Change surveys are included in the proposed budget.

Chapter 21

Mathematical Sciences in the FY 1991 Budget

Joint Policy Board for Mathematics

Hans J. Oser

Overview and General Trends

The substantial increases in support of research in mathematical science during the 1980's have generally given way to a more modest growth as seen in the proposed fiscal year 1991 federal budget. During the early eighties many funding agencies experienced annual growth rates in excess of 10 percent in their mathematics programs. In the past few years, however, the worsening federal deficit, combined with the effects of the Gramm-Rudman-Hollings legislation, has substantially cut the rate of increase for these programs.

Although the National Science Foundation (NSF) has convinced the Administration again that the overall NSF budget should double by 1993, the last three years' experience urges caution on whether NSF can expect the 14 percent increase they are asking for. The oversight committees in both Houses of Congress have been sympathetic in recent years to the idea of doubling NSF's budget over a five-year period, but the prevailing budget realities have forced Congress to deny the Administration's request for three years in a row. Besides the Gramm-Rudman-Hollings legislation, the jurisdictional boundaries of the appropriations subcommittees in both Houses have been the most serious obstacle to granting NSF the special status that it would seem to deserve as one of the nation's major sources of support for basic research in science and engineering. NSF has suffered from the annual tug of war between its own budget requests, the space program, and those highly visible programs for national housing and for veterans' affairs, the latter now a cabinet-level department.

Neither the Department of Energy nor the funding agencies in the Department of Defense predict dramatic increases in support of R&D programs, although basic research appears to come off better than many applied research and technology development programs.

The fragmentation of congressional responsibility concerning science and technology programs has prevented a meaningful dialogue on national R&D policy. This situation has frustrated members of the academic world who would like to see Congress discuss the issues of big science versus little science, the balance between defense-sponsored and civilian research, the growth, in numbers and size, of science and technology centers versus single-investigator grants, as well as the potential impact of adding technology policy to NSF's duties.

Trends in Federal Support for Mathematics between 1982-1990

In the NSF, mathematics has fared relatively well in the past eight years. Growth in the Division of Mathematical Sciences (DMS) during this period was 85 percent (in constant dollars) and even higher when mathematics-related support in other directorates is counted. Most of these increases went into development of an undergraduate mathematics curriculum. In FY 1991, the DMS is asking for a 6.7 percent increase (in current dollars), which is the second-highest in the Mathematical and Physical Sciences Directorate (MPS), after astronomy. Beginning in FY 1991, the NSF budget contains a new line item for facilities, for which $20 million is being requested. Within MPS, those funds will be directed towards upgrading laboratory facilities in physics, astronomy, and materials science, none for mathematics.

In the Defense Department, the former rapid growth in support of basic research has declined to a modest 4 percent in FY 1991. How this overall increase in the so-called 6.1 programs will show up in the FY 1991 mathematical sciences programs in ARO, AFOSR, ONR, NSA, and DARPA is not yet evident. Most of the DOD program managers indicate a practically level budget for 1991 compared to 1990. The overall growth in support of mathematics since 1982, in constant dollars, was 73 percent, but that growth has been quite uneven as we examine the five funding agencies more closely. NSA and DARPA did not directly fund mathematical science research in the universities prior to 1984. AFOSR and ARO show (constant-dollar) increases of 86 and 51 percent, respectively, while ONR suffered a 13 percent decline during the same period.

The Department of Energy is requesting an 11 percent increase in its mathematical sciences program for FY 1991. Past experience suggests that the final outcome will probably be closer to half that amount. The DOE Applied Mathematical Sciences Program supports both mathematics and computer science and divides its $25 million budget about equally between the two disciplines. About half of the budget supports university-based research projects, the other half is channeled through the DOE National Laboratories. The mathematics support directed to the universities, in constant dollars, grew by an astounding 125 percent since 1982, the highest of any of the agencies covered in this survey. This DOE program also underwrites the Wilkinson Fellowship at Argonne National Laboratory, the Lewy Fellowship at Berkeley, and the Householder Fellowship at Oak Ridge National Laboratory, all fellowships that enjoy considerable prestige in the mathematics community.

Highlights of Mathematics Programs in FY 1990

The Army Research Office announced on 24 August 1989 that it had made a 5-year, $66.9 million award to a consortium, led by the University of Minnesota, to establish an Army High Performance Computing Research Center on the Minneapolis Campus. The program envisioned by the Army will include research in the mathematical sciences, computer engineering, and physical and biological sciences. Other participants in this new center, besides the University of Minnesota, are the Massachusetts Institute of Technology, Howard University, and Purdue University. The center is expected to be fully operational in the Spring of 1990. Initially, access will be made available to supercomputers such as the CRAY-2 and CRAY-XMP, later to be augmented by an aggressive equipment acquisition of massively parallel machines, high-performance workstations, and a visualization laboratory. The equipment budget during the 5-year lifetime of the project is $27.3 million, the research budget is $8.5 million, and infrastructure support will get $31.1 million. The director of the center is George Sell, the scientific direction is provided by David Kinderlehrer in the School of Mathematics at Minnesota.

Automatic Gramm-Rudman-Hollings cuts forced NSF to postpone the start of new science and technology centers in FY 1990. The collapse of ETA-Systems, the Control Data Corporation's supercomputer subsidiary, led to an NSF decision in the directorate for Computer & Information Science and Engineering (CSE) to phase out support for the John von Neumann Center at Princeton University during the current fiscal year. The four remaining supercomputer centers (Illinois, Cornell, Pittsburgh, and San Diego) will receive hardware and software upgrades in both FY 1990 and FY 1991.

Proposed Agency Programs in the 1991 Budget

Each funding agency provides support for a variety of programs including institutes, individual and group awards, equipment awards, and special programs in support of women and minority students. In addition, all agencies are funding a variety of cross-disciplinary programs, such as infrastructure support, equipment awards, fellowships for faculty and graduate students (including women and minority fellowships), and so-called small institution awards. Agency programs are also involved in cooperative funding arrangements across disciplines and sometimes jointly with other agencies. These include industrial, university, and laboratory cooperative programs. For these reasons it is very difficult to make precise statements about the level of funding for mathematical sciences research per se, since many of the funding agencies in DOD, NASA, and in DOE often describe their programs by projects and not by discipline.

Personnel changes have been quite minimal during the past year. The new director of the mathematics division in ONR is Neil Gerr who had been acting director of the division since the departure of John Cannon. Several new program directors were appointed in NSF, AFOSR, ONR, and ARO.

A. National Science Foundation

Within the Mathematical and Physical Sciences Directorate (MPS), the FY 1991 request for mathematical sciences of $73.72 million is up from $69.12 million in 1990, a 6.7 percent increase in current dollars. The additional funds are for the Special Projects activity (undergraduate course and curriculum development, alliances for minority participation, and faculty awards for women), and in the programs area an increase of 20 new investigators, more support for graduate students and equipment, and strengthened research support in areas of opportunity, such as interaction with other disciplines, computational mathematics, and the incorporation of geometric ideas and methods throughout the mathematical sciences.

Both MPS and CSE have substantial increases for science and technology centers in their budget requests for next year, totalling $15.25 million. The awards will not be made until late 1990, when the allocation to particular disciplines will be known.

B. Air Force Office of Scientific Research (AFOSR)

Mathematical sciences research is supported within the Mathematical and Information Sciences Directorate. Support for mathematics is expected to increase from $16.5 million in fiscal year 1990 to $17.50 million in fiscal year 1991. Included in this figure are $3 million for multidisciplinary and research interaction awards under the University Research Initiative Program and about $1 million going to support research in the Air Force laboratories. Major program areas supported by the AFOSR are nonlinear dynamics and control theory, optimization, finite mathematics, signal processing and communication, probability and statistics, and physical mathematics. There is an exploratory research program in wavelets.

C. Army Research Office (ARO)

The Army High Performance Computing Research Center (AHPCRC) at the University of Minnesota is now in its first full fiscal year of operation. The research program at AHPCRC is directed towards mathematical and computer sciences, physics and biology. Programmatic thrusts are in the materials sciences, real-time control, computer science aspects in large-scale computing and in the biomedical sciences. ARO also supports the Mathematical Sciences Institute at Cornell University and the Center for Intelligent Systems at Brown and Harvard Universities.

D. Office of Naval Research (ONR)

The Mathematical Sciences Division's program is divided into six areas: applied analysis, discrete mathematics, numerical analysis, operations research, probability and statistics, and signal analysis. The core program

Principal Federal Statistical Agencies
(budget authority in millions)

	FY 1989 Actual	FY 1990 Est.[5]	FY 1991 Budget
Bureau of the Census (current programs)[1].........	$ 96.0	$ 99.9	$115.2
Bureau of Labor Statistics.........................	233.8	241.4	252.8
Bureau of Economic Analysis........................	24.8	25.6	34.3
Statistics of Income, IRS..........................	19.3	19.7	21.2
National Agricultural Statistics Service..........	63.6	66.9	81.2
Economic Research Service, USDA[2].................	49.3	50.7	56.3
Energy Information Administration.................	62.9	64.3	66.6
National Center for Health Statistics[3]...........	48.4	48.5	48.1
National Center for Education Statistics[4]........	31.1	39.7	60.4
Bureau of Justice Statistics[4]....................	20.0	20.9	23.1
Policy Development and Research, HUD..............	12.5	13.0	14.7

Notes: [1]The proposed FY 1991 budget for periodic programs at the Bureau of the Census is $316.1 million; these funds would be used to complete 1990 Decennial Census data collection activities, begin planning for the 2000 Decennial Census, and prepare for the 1992 Economic Censuses. [2]Approximately 20 percent of the Economic Research Service budget, shown here in total, is used for surveys, data collection, and preparation of statistical reports. [3]As indicated in the text, the FY 1991 budget also proposes to provide $19.0 million from Public Health Service Evaluation Funds to support programs of NCHS. [4]Budget levels shown for NCES and BJS do not include S&E from other departmental sources. For FY 1991, NCES will have an estimated $9.1 million in S&E budget, and BJS will have an estimated $2.7 million in S&E budget. [5]FY 1990 figures reflect the sequester pursuant to P.L. 99-177.

in FY 1990 is $7 million and is expected to increase to almost $8 million in 1991. The accelerated research initiatives (ARI) are short-term programs with typically a five-year lifetime. Their share of the mathematics budget this year is $4 million and is expected to go up to $4.8 million in FY 1991. The total budget of the division will thus increase from $11 million to $12.7 million in FY 1991, a growth of over 15 percent in current dollars. This is the first substantial increase in several years for the mathematics program at ONR.

E. Defense Advanced Research Programs Agency (DARPA)

Unlike the funding agencies of the three DOD Services, i.e., AFOSR, ARO, and ONR, the DARPA program is directed towards advanced technology development. Mathematical research is but one tool in the arsenal of techniques employed to further DARPA's goals. Furthermore, the distinction between applied mathematics, computer science and computer engineering is an exceedingly difficult one to draw in this environment. Consequently, the allocation of the agency's budget to particular disciplines is not entirely satisfactory in this case.

In FY 1990 the Applied Computational and Mathematics Program has a total budget of $12 million. This program is primarily directed toward four specific areas. They are (1) modeling and simulation, (2) algorithmic development, (3) digital signal processing, and (4) intelligent control. This latter category of research is directed towards those aspects of control theory where the environment cannot be described by ordinary differential equations any more but has to be determined through modeling, simulation and heuristics. That also involves the use of artificial intelligence (AI) methods for data management.

In digital signal processing, new tools are being developed, such as wavelets, Gabor bases. and Wigner transforms. Data fusion is a technique that is being used to combine information from the data to which different computations have been applied.

Algorithm development aims at codes for distributed sys-tems, among them non-iterative algorithms for number-crunching in linear algebra problems. Another goal is the automation of optimal code generation that will match given algorithms to a particular machine.

F. National Security Agency (NSA)

NSA's mathematical sciences program experienced a substantial increase from fiscal year 1989 to 1990, from $2.9 million to $3.2 million, or more than 10 percent. The outlook for fiscal year 1991 appears to be for a level budget.

The mathematical sciences program at NSA went public in 1984. It supports research in algebra, number theory, discrete mathematics, statistics and probability. Due to the nature of its work, the agency continues to be concerned about the supply of U.S. citizens for its ongoing mission.

G. Department of Energy (DOE)

The Applied Mathematical Sciences program in the DOE Office of Energy Research serves two distinct roles. Mathematical sciences research is aimed at understanding models arising in DOE research and development programs and to provide supercomputing resources to DOE's researchers. Growth of these programs continued in 1989 and 1990. The applied mathematical sciences research program funds basic research in the national laboratories, universities, and private research institutions, in these categories: analytic and numerical methods, computational statistics, information analysis techniques, and advanced computing concepts for parallel architectures and languages. Topical areas of mathematics that are supported include: applied analysis, discrete mathematics, statistics and probability, linear algebra, optimization and control, geometry, dynamical systems, and nonlinear analysis.

Support for computer science and mathematics is split about evenly between U.S. universities and the DOE National Laboratories (which happen to be managed by universities in several cases). The dollar figures in this chapter reflect only the research support for the mathematical sciences. For computer science, see the appropriate chapter in this report.

The table on the next page shows the budgets for the years between 1983 and 1991 for the federal agencies that have supported mathematical research . As before, we have updated some of the figures from prior years as better information has become available.

H. Other Federal Agencies

Several agencies, such as the National Aeronautics and Space Administration and the National Institutes of Health, support mathematical sciences programs, though mostly in-house. NASA also supports the Institute for Computer Applications in Science and Engineering in Langley, VA, with a budget of approximately $1 million annually. The National Institute of Standards and Technology, as well as numerous national laboratories in other federal agencies, conduct substantial in-house mathematics, statistics, and computer science research programs.

Footnotes to table on left page

(1) Includes estimates for S/T Centers after FY 1988

(2) Some DOD programs include University Research Initiatives (URI)

(3) The DOE Mathematical Sciences Program also supports computer science programs at about the same level

Chapter 22

Computer Science and Engineering Support in the FY 1991 Budget

The Computing Research Board

Terry M. Walker

Introduction:

Federal support for R&D can be divided into two basic categories according to source: *defense* and *civilian*. More than 60% of total federal R&D expenditures in computer science and engineering (CS&E) are supported by the defense sector. This section will address federal funding for CS&E R&D as proposed for FY 1991 by civilian and defense categories.

R&D funding can also be classified into three categories, according to type of research: *basic research* (defense classification 6.1), *applied research* (defense classification 6.2), and *development* (defense classification 6.3). Federal budget documents do not provide details on the division of R&D funding among these three categories. Although the majority of defense R&D funding in CS&E falls into categories 6.2 and 6.3, DoD is a significant funding source for basic research in computing. On the other hand, the majority of civilian funding (primarily from NSF) clearly is in support of basic research.

Finally, federal R&D activities are conducted in government and non-university labs as well as in universities. The majority of the funding for CS&E research is in support of activities outside of universities.

The remaining portions of this section will outline the level of federal funding that can be expected for R&D in CS&E during FY 1991. As analysis will indicate, the funding levels for CS&E R&D may prove to be inadequate because of: (1) a failure to include funding for the High Performance Computing Program (HPCP), (2) fairly static budgets for the defense sector, and (3) budget requests may not be fully funded. As in previous years, the three largest sources of funds for R&D in CS&E are, in decreasing order of funding, DARPA, NSF, and ONR.

Where available, all data presented in this chapter will be for the five fiscal years beginning with FY 1986 together with the proposed budget for FY 1991. Data will be presented in both current dollars as well as in deflated ones, the latter being provided to indicate the true purchasing power of research funds. Deflated data have been derived using both OMB-supplied deflators and more realistic figures based upon an inflation rate in CS&E salaries of about 6 percent per year since FY 1986 (as determined by CRB Taulbee survey and

AAUP faculty salary data). Use of the latter deflated values can be justified given that the most significant cost in virtually all research budgets is personnel. Use of the OMB and 6 percent CRB deflators will be clearly delineated in this section. Finally, the percentage change for FY 1991 over FY 1990 has been calculated using the difference between the FY 1990 current plan data and the FY 1991 budget requests. This method does not reflect the fact that budget requests are often not fully funded. For example, the NSF FY 1990 appropriation was more than 11 percent below the FY 1990 budget request.

Overall Funding By Areas:

On the surface, the proposed Bush budget for FY 1991 provides dramatic increases in some areas of CS&E R&D. For example, press releases indicate an overall increase in support for robotics R&D of 28 percent, for a total expenditure of almost $200 million. An increase of 5 percent (to about $450 million) is forecast for high performance computing and a 2 percent increase (to about $525 million) for R&D on semiconductor technology. However, the allocation of funding to the various research areas in CS&E is difficult to ascertain, particularly outside of NSF, because few details on the budget are available. Further, much of the DoD R&D funding increase may be weighted heavily on the side of *D*, with little, if any, increase on the *R* side. Of particular concern is the nominal amount of any R&D increases that are likely to be directed towards universities for basic research.

Civilian Funding:

The largest source of civilian funding for R&D in CS&E is the National Science Foundation (NSF). NSF is also the largest source of funding for basic research in the field. Federal support for CS&E R&D is administered through the Computer and Information Science and Engineering Directorate (CISE) within NSF. Not all of the CISE budget is dedicated to R&D in CS&E. Thus, the non-CS&E activities should be factored from the CISE budget to determine the level of research support for CS&E R&D.

Two examples of R&D activities included in the CISE budget that are only partially in support of CS&E research are funding for the operation of the Supercomputer Research Centers and operation of the NSFNET. Funding for both of these programs supports services provided to a variety of constituencies. The Supercomputer Research Centers provide computing support for researchers from all science and engineering disciplines, with only about one percent of their usage being by CS&E researchers (according to data published in the FY 1990 NSF Detailed Budget Request). Similarly, NSFNET is a networking facility used by persons from all science and engineering disciplines, with less than 50 percent of the utilization estimated to be by CS&E researchers.

Table 1A contains the proposed CISE total budget in current dollars. This indicates that the overall CISE budget for FY 1991 is projected to increase by 13.8 percent over FY 1990. The slight decrease in the budget for the Advanced Scientific Computing program is the result of the termination of the John von Neumann Center at Princeton. Increases in several of the CISE research programs seem promising. For example, the Science Research Centers and the

Networking and Cross-Disciplinary Activities Divisions are programmed for substantial increases. The Computer and Computational Research Division, the Information, Robotics, and Intelligent Systems Division, and the Microelectronics Information Processing Systems Division are programmed for sizable increases.

Table 1B contains data using a stricter interpretation of the research components of the CISE Directorate. This budget consists of the full CISE budget less the support for the Supercomputing Research Centers. The Supercomputing Research Centers are eliminated because their primary function is not to provide support for research in CS&E; instead, they are operational entities that support research in other science and engineering disciplines. Note that the New Technologies component of the Advanced Scientific Computing Division is retained since it consists of small research grants in support of basic research. All of NSFNET funding has been included even though it is an operational activity that supports general science and engineering communications because solid data is not available on the portion of NSFNET expenditures that is in support of CS&E R&D. More than an estimated 50 percent of the NSFNET budget amount should be removed as not being in support of CS&E R&D (as was observed earlier), but this reduction has not been made in any of the data tables. The Networking and Communications Research component of the Networking and Communications Research and Infrastructure Division is retained because it consists of small research grants in support of basic CS&E research. The stricter interpretation of the CISE budget provided in Table 1B indicates a somewhat more positive increase in funding for CISE.

Table 2A contains the proposed CISE total budget in deflated dollars, where deflation is defined by the very conservative OMB figures. This indicates that the overall CISE budget for FY 1991 is projected to increase by 9.2 percent from FY 1990. Again, the decrease in the budget for the Advanced Scientific Computing program masks increases in several of the CISE research programs. In particular, the Science Research Centers and the Networking Division are programmed for substantial increases. The Cross-Disciplinary Activities Division is programmed for a sizable increase, while the Computer and

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Legend for Tables 1A - 3B

NSF:	National Science Foundation
CISE:	Computer & Information Science & Engineering Directorate (NSF)
CCR:	Computer & Computation Research Division (CISE)
IRIS:	Information, Robotics & Intelligent Systems Division (CISE)
MIPS:	Microelectronics Information Processing Systems Division (CISE)
ASC:	Advanced Scientific Computing Division (CISE)
NCRI	Networking & Communications Research & Infrastructure Division (CISE)
CDA:	Cross-Disciplinary Activities Division (CISE)
STC	Science & Technology Centers (CISE)

FEDERAL AGENCY SUPPORT IN THE MATHEMATICAL SCIENCES (IN MILLIONS OF DOLLARS), 1983-1991

	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89	FY 90	FY 91
NAT. SCIENCE FOUNDATION									
DMS	34.10	41.20	47.50	51.74	59.42	63.76	66.02	69.12	73.72
Other (1)	3.00	4.00	5.00	5.50	5.00	5.50	8.00	8.00	10.00
Total NSF	37.10	45.20	52.50	57.24	64.42	69.26	74.02	77.12	83.72
DEPARTMENT OF DEFENSE (2)									
AFOSR	7.30	10.20	11.82	13.30	15.30	14.30	16.45	16.50	17.50
ARO	6.50	6.80	7.50	8.40	9.70	10.60	11.50	12.00	12.00
ONR	12.70	11.90	11.98	12.81	11.30	11.50	12.02	12.70	14.13
DARPA	-	-	1.00	5.50	9.20	12.00	12.00	12.00	12.00
NSA	-	1.02	1.32	1.62	1.90	2.31	2.86	3.20	3.20
Total DOD	26.50	29.92	33.62	41.63	47.40	50.71	54.83	56.40	58.83
DEPARTMENT OF ENERGY (3)									
University Support	2.80	2.90	3.50	3.94	4.30	5.90	5.70	6.40	6.50
National Laboratories	3.90	4.30	5.10	5.80	5.50	5.90	6.50	6.50	7.00
Total DOE	6.70	7.20	8.60	9.74	9.80	11.80	12.20	12.90	13.50
OTHER AGENCIES	2.00	2.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00
TOTAL NON-NSF	35.20	39.12	44.22	53.37	58.20	63.51	68.03	70.30	73.33
GRAND TOTAL-All Agencies	72.30	84.32	96.72	110.61	122.62	132.77	142.05	147.42	157.05

Table 1A *NSF CISE Total Budget in Current Dollars (in millions)*

	FY86	FY87	FY88	FY88	FY89	FY89	FY90	FY90	FY91	%Change	%Change	%Change	%Change	%Change	%Change
	Actual	Actual	Request	Actual	Request	Actual	Request	Curr Plan	Request	FY86-87	FY87-88	FY88-89	FY89-90	FY90-91	FY86-90
CCR	16.98	19.04	23.35	19.85	22.30	21.17	23.67	21.98	24.28	12.13	4.25	6.65	3.83	10.46	29.45
IRIS	15.09	17.02	19.87	17.73	19.85	19.14	21.64	19.98	22.88	12.79	4.17	7.95	4.39	14.51	32.41
MIPS	7.28	11.61	18.21	13.29	16.00	14.98	18.95	16.61	18.87	59.48	14.47	12.72	10.88	13.61	128.16
ASC	36.47	43.05	48.20	44.70	55.80	55.58	71.69	62.83	62.58	18.04	3.83	24.34	13.04	-0.40	72.28
NCRI	8.56	9.82	13.37	11.47	17.68	17.61	27.13	22.19	31.29	14.72	16.80	53.53	26.01	41.01	159.23
CDA	16.50	16.32	20.00	16.87	17.50	17.44	21.42	19.63	24.03	-1.09	3.37	3.38	12.56	22.41	18.97
STC	0.00	0.00	0.00	0.00	0.00	5.92	6.70	6.57	9.32	0.00	0.00	0.00	10.98	41.86	0.00
Totals:	100.88	116.86	143.00	123.91	149.13	151.84	191.20	169.79	193.25	15.84	6.03	22.54	11.82	13.82	68.31

Table 1B *NSF CISE CS&E Research Budget in Current Dollars (in millions)*

	FY86	FY87	FY88	FY88	FY89	FY89	FY90	FY90	FY91	%Change	%Change	%Change	%Change	%Change	%Change
	Actual	Actual	Request	Actual	Request	Actual	Request	Curr Plan	Request	FY86-87	FY87-88	FY88-89	FY89-90	FY90-91	FY86-90
CCR	16.98	19.04	23.35	19.85	22.30	21.17	23.67	21.98	24.28	12.13	4.25	6.65	3.83	10.46	29.45
IRIS	15.09	17.02	19.87	17.73	19.85	19.14	21.64	19.98	22.88	12.79	4.17	7.95	4.39	14.51	32.41
MIPS	7.28	11.61	18.21	13.29	16.00	14.98	18.95	16.61	18.87	59.48	14.47	12.72	10.88	13.61	128.16
ASC	1.55	3.71	1.60	1.77	1.80	1.79	2.66	2.62	2.99	139.35	-52.29	1.13	46.37	14.12	69.03
NCRI	8.56	9.82	13.37	11.47	17.68	17.61	27.13	22.19	31.29	14.72	16.80	53.53	26.01	41.01	159.23
CDA	16.50	16.32	20.00	16.87	17.50	17.44	21.42	19.63	24.03	-1.09	3.37	3.38	12.56	22.41	18.97
STC	0.00	0.00	0.00	0.00	0.00	5.92	6.70	6.57	9.32	0.00	0.00	0.00	10.98	41.86	0.00
Totals:	65.96	77.52	96.40	80.98	95.13	98.05	122.17	109.58	133.66	17.53	4.46	21.08	11.76	21.97	66.13

Table 2A *NSF CISE Total Budget in OMB Deflated Dollars (in millions)*

	FY86	FY87	FY88	FY88	FY89	FY89	FY90	FY90	FY91	%Change	%Change	%Change	%Change	%Change	%Change
	Actual	Actual	Request	Actual	Request	Actual	Request	Curr Plan	Request	FY86-87	FY87-88	FY88-89	FY89-90	FY90-91	FY86-90
CCR	14.71	16.08	19.06	16.20	17.40	16.52	17.76	16.49	17.48	9.27	0.77	1.99	-0.18	6.01	12.11
IRIS	13.07	14.37	16.22	14.47	15.49	14.94	16.24	14.99	16.48	9.91	0.69	3.23	0.36	9.90	14.67
MIPS	6.31	9.80	14.86	10.85	12.49	11.69	14.22	12.46	13.59	55.41	10.65	7.79	6.60	9.03	97.60
ASC	31.60	36.35	39.34	36.48	43.55	43.38	53.79	47.14	45.06	15.03	0.37	18.91	8.68	-4.41	49.20
NCRI	7.42	8.29	10.91	9.36	13.80	13.74	20.36	16.65	22.53	11.79	12.90	46.82	21.15	35.32	124.51
CDA	14.30	13.78	16.32	13.77	13.66	13.61	16.07	14.73	17.30	-3.61	-0.08	-1.14	8.22	17.48	3.04
STC	0.00	0.00	0.00	0.00	0.00	4.62	5.03	4.93	6.71	0.00	0.00	0.00	6.70	36.14	0.00
Totals:	87.40	98.67	116.71	101.13	116.39	118.50	143.47	127.40	139.16	12.89	2.49	17.18	7.51	9.23	45.77

Table 2B *NSF CISE CS&E Research Budget in OMB Deflated Dollars (in millions)*

	FY86	FY87	FY88	FY88	FY89	FY89	FY90	FY90	FY91	%Change	%Change	%Change	%Change	%Change	%Change
	Actual	Actual	Request	Actual	Request	Actual	Request	Curr Plan	Request	FY86-87	FY87-88	FY88-89	FY89-90	FY90-91	FY86-90
CCR	14.71	16.08	19.06	16.20	17.40	16.52	17.76	16.49	17.48	9.27	0.77	1.99	-0.18	6.01	12.11
IRIS	13.07	14.37	16.22	14.47	15.49	14.94	16.24	14.99	16.48	9.91	0.69	3.23	0.36	9.90	14.67
MIPS	6.31	9.80	14.86	10.85	12.49	11.69	14.22	12.46	13.59	55.41	10.65	7.79	6.60	9.03	97.60
ASC	1.34	3.13	1.31	1.44	1.40	1.40	2.00	1.97	2.15	133.25	-53.88	-3.29	40.72	9.52	46.39
NCRI	7.42	8.29	10.91	9.36	13.80	13.74	20.36	16.65	22.53	11.79	12.90	46.82	21.15	35.32	124.51
CDA	14.30	13.78	16.32	13.77	13.66	13.61	16.07	14.73	17.30	-3.61	-0.08	-1.14	8.22	17.48	3.04
STC	0.00	0.00	0.00	0.00	0.00	4.62	5.03	4.93	6.71	0.00	0.00	0.00	6.70	36.14	0.00
Totals:	57.15	65.45	78.67	66.09	74.24	76.52	91.67	82.22	96.25	14.53	0.98	15.79	7.45	17.06	43.88

Computational Research Division, the Information, Robotics, and Intelligent Systems Division, and the Microelectronics Information Processing Systems Division are programmed for more modest increases in deflated dollars.

Table 2B contains data for the stricter interpretation of the research components of the CISE Directorate in deflated dollars, where deflation is defined by the very conservative OMB figures. This budget is identical to the one appearing in Table 1B, but has been adjusted for inflation. The strict interpretation of the CISE budget in deflated dollars provided in Table 2B indicates a still sizable increase in funding for the research component of CISE. However, assuming the same ratio of funding to request as in FY 1990, the real CISE budget increase would only be about 4 percent.

Table 3A contains the proposed CISE total budget in deflated dollars, where deflation is defined by the more realistic figures assuming an inflation rate in CS&E R&D since 1986 of 6 percent per year. This indicates that the overall CISE budget for FY 1991 is projected to increase by 7 percent from FY 1990. In fact, only three of the seven CISE Divisions show an increase of more than 10 percent using these deflator values. None of them are the individual-investigator-oriented basic research components of CISE. Again, assuming the same ratio of funding to request for FY 1991 as in FY 1990, the projected overall CISE budget would actually decrease by 4.7 percent in real terms.

Table 3B contains data for the stricter interpretation of the research components of the CISE Directorate in deflated dollars, where deflation is defined by the more realistic figures assuming an inflation rate in CS&E R&D since 1986 of 6 percent per year. This budget is identical to the one appearing in Table 1B, but has been adjusted for inflation. The strict interpretation of the CISE budget in deflated dollars provided in Table 3B indicates a real increase of 15.07 percent in funding for the research component of CISE. Again, assuming the same ratio of funding to request as in FY 1990, the real CISE budget increase would be only about 2.2 percent.

Given that the number of faculty members in CS&E departments performing R&D has been increasing at the rate of about 10 percent per year (based upon Taulbee survey data), modest real increases in funding from NSF portend significant problems ahead for CS&E researchers.

Other civilian agencies which sponsor CS&E R&D are the Department of Energy (DoE), the National Institute for Standards and Technology (NIST) of the Department of Commerce (DoC), the National Aeronautics and Space Administration (NASA), the National Institutes of Health (NIH), and the National Oceanic and Atmospheric Agency (NOAA). Of these, the most significant are DoE and NASA, data for which were not available. NIST and NIH are not significant supporters of CS&E R&D and therefore were not included in this section.

Defense Funding:

Proposed and historical data for the levels of defense agency R&D funding by discipline are very difficult to obtain. The data is aggregated by weapons programs and in other ways in the Executive Budget that is sent to Congress, which makes it extremely difficult to attribute particular research support to CS&E, let alone to a particular subdiscipline. Further, the budgets of the various agencies often evolve as the fiscal year approaches, depending on the priorities of the various services. Thus, the budgets presented in this section generally lack detail and, in some cases, are rather gross estimates.

The best estimates of current dollar funding for the various defense agencies appear in Table 4. As was noted earlier, defense funding in CS&E R&D is dominated by DARPA. Based upon estimates provided by DARPA, funding for CS&E R&D for FY 1991 is expected to be flat. A similar situation holds for AFOSR. In contrast, ONR expects a modest increase in its budget for CS&E R&D. We might note that, while DARPA provides a mixture of support relative to 6.1, 6.2 and 6.3 activities, almost all funding from the various service research offices is 6.1 (basic research) funding.

Tables showing deflated values, which have not been included in this section, illustrate that the relatively level CS&E R&D funding situation for most DoD agencies during the past several years has resulted in real declines in support. For example, using the 6 percent rate of inflation for CS&E R&D, the funding level at DARPA has declined by a total of 4.5 percent between FY 1986 and FY 1990, with an additional decline of about 4.1 percent projected for FY 1991. Similarly, CS&E R&D funding at ONR has declined 20.2 percent between FY 1986 and FY 1990, with an increase of 6.3 percent projected for FY 1991.

Other DoD agencies which support CS&E R&D are the Office of the Secretary of Defense (OSD), the Strategic Defense Initiative Organization (SDIO), and the National Security Agency (NSA). These agencies either are not significant funding sources for CS&E R&D or would not furnish useful data for this study.

Legend for Table 4

N/A:	Data Not Made Available by Agency
DoD:	Department of Defense
AFOSR:	Air Force Office of Scientific Research (DoD)
NAI:	Non-Artificial Intelligence
AI:	Artificial Intelligence
ARO:	Army Research Office (DoD)
DARPA:	Defense Advanced Research Projects Agency (DoD)
ONR:	Office of Naval Research (DoD)
ISR:	Intelligent Systems Research Program (ONR)
SSR:	Software Systems Research Program (ONR)
CSR:	Computer Systems Research Program (ONR)
MSR:	Manufacturing Science Research Program (ONR)

Chapter 23

Electrotechnology-Related Research in the FY 1991 Budget

Institute of Electrical and Electronics Engineers - United States Activities

Chris J. Brantley

Electrotechnology is a major beneficiary of the Bush Administration's emphasis on enhancing federal research and development (R&D). This report provides an overview of proposed funding for electrotechnology-related R&D programs in the Administration's FY 1990 budget proposal to Congress.

The report highlights those key electrical and electronics technologies which are either the major beneficiary or the primary means of achieving the objective of the research. It is not intended to be all inclusive, as time and space limitations preclude reporting on all relevant programs relating to electrotechnology within the $71.2 billion in federal R&D obligatory authority requested for FY 1991.

The analysis has been prepared primarily on the basis of budget figures provided by the federal departments and agencies on January 29, 1990, when the Administration's budget was released to Congress.

You might note minor variations between the numbers presented here and those in the agency budget charts presented elsewhere in this book, the result of adjustments to the line items that constitute research and development. In all instances such variations should be miniscule in comparison with the overall numbers, and should not significantly affect the trends presented herein.

DEPARTMENT OF DEFENSE

Responding to lessening tensions between the superpowers and concern over the federal deficit, the Administration has proposed an annual real decrease of 2 percent in defense spending through FY 1995. The FY 1991 Department of Defense (DoD) budget request of $295.1 billion reflects a decrease of 2.6 percent when adjusted for inflation. Within that budget, spending for Research, Development, Test and Evaluation (RDT&E) is slated to increase approximately 4 percent to $38.09 billion.

Technology Base programs, that component of RDT&E traditionally devoted to research and development activity, reversed its slide as a percentage of the total RDT&E budget, stabilizing at 9 percent. Technology Base funding rises 3 percent to $3.4 billion and includes increases of 6 percent for Research (to $977.8 million) and 2 percent for Exploratory Development (to $2.46 billion).

Allocation of these funds varies through the Triservices and Defense Agencies. Below is a brief overview with highlights of program elements of particular relevance to electrical and electronics engineering:

Army

Total funds allocated for Army RDT&E would increase 11 percent to $6.026 billion in FY 1991.

The allocation for Army Research would total $188.9 million, an increase of 4 percent over FY 1990. Exploratory Development increases 6 percent to $579.9 million. Among programs of interest:

• Materials Technology	+ 23.4%	$13.3 million
• Electronic Survivability and Fuzing Technology	- 6.5%	$24.9 million
• Laser Weapons Technology	+ 2.8%	$ .5 million
• Electronics and Electronic Devices	+ 2.1%	$17.6 million
• Command, Control and Communications Tech.	+ 31.3%	$20.5 million
• Computer and Software Technology	+ 46.4%	$ 5.1 million

Advanced Technology Development would decrease almost 6 percent to $485 million. Among programs of interest:

C^3 Advanced Technology	+ 18.5%	$ 9.3 million
Electronic Warfare Tech.	-100.0%	$ - 0 -
Missile and Rocket Advanced Technology	- 16.2%	$ 8.8 million
Night Vision Advanced Technology	- 5.4%	$20.3 million
Advanced Electronic Devices Development	- 27.1%	$ 5.6 million
Advanced Tactical Computer Science and Technology	+ 9.7%	$ 4.8 million

Navy

The Navy's RDT&E budget decreases 4 percent to 9.1 billion in FY 1991. Research would increase 9.6 percent to $401.2 million. Defense Research Sciences would grow by $32.8 million to $374.4 million. Exploratory Development in the Navy increases 6 percent to $466.3 million. Exploratory programs of interest include:

C^3 Technology	+ 18.6%	$18.4 million
Electronic Warfare Tech.	+ 3.1%	$12.9 million
ASW Technology	+ 11.2%	$16.7 million
Nuclear Propulsion	+ 3.8%	$14.6 million

Although Advanced Technology Development would decrease 7 percent to $199.6 million, several key programs show increases:

Electromagnetic Radiation Sources Elimination	+489.3%	$ 5.7 million
Electric Drive	+ 40.4%	$43.8 million
Simulation and Training Devices	+ 41.8%	$ 5.0 million
Advanced ASW Technology	- 56.1%	$16.4 million

Air Force

Air Force RDT&E would decrease by approximately 2 percent in FY 1991 to $13.3 billion. The Research component would receive a 6 percent increase to $201.5 million.

Air Force Exploratory Development would increase 2.5 percent to $580 million. Among programs of interest:

• Materials	+ 5.5%	$60.8 million
• Aerospace Avionics	+ 6.5%	$68.6 million
• C3	- 1.3%	$79.4 million

Advanced Technology Development would increase only 1 percent to $646.1 million. Within this category, several programs showed significant increases:

• Advanced Avionics for Aerospace Vehicles	+ 32.2%	$32.3 million
• Advanced Avionics Integration	+ 8.0%	$15.1 million
• Electronic Warfare Tech.	+ 14.7%	$36.9 million
• Advanced Computer Tech.	+ 19.3%	$ 9.1 million
• C^3 Advanced Development	+ 12.9%	$ 9.6 million
• C^3I Subsystem Integration	+ 26.5%	$ 9.5 million

Defense Agencies

RDT&E across the Defense Agencies would increase by 13.6 percent to $9.25 billion. Two of the three primary R&D funding agencies are slated for increases.

The Strategic Defense Initiative Organization (SDIO) would increase 25% to 4.46 billion in FY 1991. An additional $192 million is budgeted for SDI research in the Department of Energy. Facing the prospect of deep cuts by Congress, the Administration has reported that it will give priority to Phase I development of the Strategic Defense System with $265 million budgeted for engineering of the Boost Surveillance and Tracking System.

Although all SDIO research is classified under Advanced Development, there is a significant element of basic research. SDIO program lines include:

• Surveillance, Acquisition Tracking and Kill Assessment	+ 6.0%	$1.31 billion
• Directed Energy Weapons	+ 14.2%	$ 803 million
• Kinetic Energy Weapons	+ 36.7%	$1.01 billion
• Systems and Battle Mgmnt.	+ 22.6%	$ 674 million
• Survivability, Lethality, and Key Support Tech.	+ 15.4%	$ 394 million

The Defense Nuclear Agency would also increase 25 percent to $446 million. This includes Technology Base funding of $370 million, up 9.5 percent, and $76 million for Verification Technology Demonstrations, an increase of 300 percent.

The Defense Advanced Research Projects Agency (DARPA) would suffer a 12 percent reduction to $1.08 billion. DARPA Technology Base programs would decline 7.5 percent to $546.3 million. Among programs of interest:

• Strategic Technology	+ 11.2%	$207.7 million
• Tactical Technology	+ 0.8%	$121.5 million
• Partical Beam Technology	+ 3.6%	$ 14.5 million
• Integrated Command and Control Technology	- 29.0%	$ 37.6 million
• Materials and Electronics Technology	- 23.5%	$ 43.1 million

Advanced Technology Development within DARPA also declines, by 17 percent to $508.2 million. Programs of interest include:

• Microwave/Millimeter Wave Monolithic Integrated Circuits	+ 10.8%	$ 86.7 million
• Prototyping of Advanced Technologies and Innovative Concepts	- 20.7%	$ 64.2 million
• Semiconducter Manufacturing Technology (SEMATECH)	+ 0.0%	$100.0 million
• Consolidated DoD Software Initiative	+ 6.6%	$ 34.6 million
• Infrared Focal Plane Array	+ 8.8%	$ 20.7 million

DEPARTMENT OF ENERGY

Total FY 1990 budget authority for the Department of Energy would increase 6.4 percent to almost $17.5 billion. Defense-related programs including research, defense materials production and Defense Waste and Environmental Restoration remain approximately 60 percent of the Department's budget.

Table 3A *NSF CISE Total Budget in CS&E 6% Inflation Deflated Dollars (in millions)*

	FY86	FY87	FY88	FY88	FY89	FY89	FY90	FY90	FY91	%Change	%Change	%Change	%Change	%Change	%Change
	Actual	Actual	Request	Actual	Request	Actual	Request	Curr Plan	Request	FY86-87	FY87-88	FY88-89	FY89-90	FY90-91	FY86-90
CCR	14.71	15.56	18.01	15.31	16.22	15.40	16.24	15.08	15.72	5.78	-1.65	0.61	-2.05	4.21	2.53
IRIS	13.07	13.91	15.32	13.67	14.44	13.92	14.85	13.71	14.81	6.41	-1.72	1.84	-1.52	8.03	4.88
MIPS	6.31	9.49	14.04	10.25	11.64	10.90	13.00	11.40	12.22	50.45	7.99	6.34	4.60	7.18	80.72
ASC	31.60	35.19	37.17	34.47	40.59	40.43	49.20	43.12	40.52	11.36	-2.04	17.30	6.65	-6.04	36.46
NCRI	7.42	8.03	10.31	8.84	12.86	12.81	18.62	15.23	20.26	8.23	10.19	44.84	18.88	33.03	105.33
CDA	14.30	13.34	15.42	13.01	12.73	12.69	14.70	13.47	15.56	-6.69	-2.48	-2.47	6.19	15.49	-5.76
STC	0.00	0.00	0.00	0.00	0.00	4.31	4.60	4.51	6.03	0.00	0.00	0.00	4.70	33.83	0.00
Totals:	87.40	95.52	110.27	95.55	108.48	110.46	131.21	116.52	125.11	9.28	0.03	15.60	5.49	7.37	33.32

Table 3B *NSF CISE CS&E Research Budget in 6%-Inflation Deflated Dollars (in millions)*

	FY86	FY87	FY88	FY88	FY89	FY89	FY90	FY90	FY91	%Change	%Change	%Change	%Change	%Change	%Change
	Actual	Actual	Request	Actual	Request	Actual	Request	Curr Plan	Request	FY86-87	FY87-88	FY88-89	FY89-90	FY90-91	FY86-90
CCR	14.71	15.56	18.01	15.31	16.22	15.40	16.24	15.08	15.72	5.78	-1.65	0.61	-2.05	4.21	2.53
IRIS	13.07	13.91	15.32	13.67	14.44	13.92	14.85	13.71	14.81	6.41	-1.72	1.84	-1.52	8.03	4.88
MIPS	6.31	9.49	14.04	10.25	11.64	10.90	13.00	11.40	12.22	50.45	7.99	6.34	4.60	7.18	80.72
ASC	1.34	3.03	1.23	1.36	1.31	1.30	1.83	1.80	1.94	125.81	-54.99	-4.59	38.08	7.66	33.89
NCRI	7.42	8.03	10.31	8.84	12.86	12.81	18.62	15.23	20.26	8.23	10.19	44.84	18.88	33.03	105.33
CDA	14.30	13.34	15.42	13.01	12.73	12.69	14.70	13.47	15.56	-6.69	-2.48	-2.47	6.19	15.49	-5.76
STC	0.00	0.00	0.00	0.00	0.00	4.31	4.60	4.51	6.03	0.00	0.00	0.00	4.70	33.83	0.00
Totals:	57.15	63.36	74.33	62.44	69.20	71.33	83.84	75.20	86.53	10.87	-1.45	14.23	5.43	15.07	31.59

Table 4 *Defense Total Budget in Current Dollars (in millions)*

	FY86 Actual	FY87 Actual	FY88 Actual	FY89 Actual	FY90 Curr Plan	FY91 Request	%Change FY86-87	%Change FY87-88	%Change FY88-89	%Change FY89-90	%Change FY90-91	%Change FY86-90
AFOSR:												
NAI	2.00	2.00	2.00	2.00	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
AI	3.00	3.00	3.00	3.00	3.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals:	5.00	5.00	5.00	5.00	5.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
ARO:												
Totals:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DARPA:												
Totals:	204.00	191.00	214.00	255.00	246.00	250.00	-6.37	12.04	19.16	-3.53	1.63	20.59
ONR:												
ISR	5.00	4.00	5.00	5.00	5.00	5.00	-20.00	25.00	0.00	0.00	0.00	0.00
SSR	3.00	2.00	4.00	4.00	2.50	3.50	-33.33	100.00	0.00	-37.50	40.00	-16.67
CSR	4.00	2.50	5.00	5.00	4.00	5.00	-37.50	100.00	0.00	-20.00	25.00	0.00
MSR	2.10	1.40	2.80	2.50	2.70	2.50	-33.33	100.00	-10.71	8.00	-7.41	28.57
Totals:	14.10	9.90	16.80	16.50	14.20	16.00	-29.79	69.70	-1.79	-13.94	12.68	0.71

Among DOE's civilian R&D programs, major emphasis is given to securing future energy supplies and enhancing basic research. A third broad focus, increasing energy conservation and efficiency, is funded at $203.2 million, slightly below the FY 1990 level.

General Science and Research is a major beneficiary of energy budget increases, rising approximately 16 percent to $1.27 billion. Identified as a major element of President Bush's R&D budget thrust, the Superconducting Supercollider (SSC) receives a 42 percent increase to $317.7 million with new funds targeted for completion of diapole magnet designs, acquisition of capital equipment and construction. A recent design review identifying significant unanticipated costs, however, has spurred a follow-up review of the project cost, scope and schedule. Funding for High Energy Physics increases 7 percent to $621.2 million to support the three DOE High Energy Accelerator Centers and for the Fermilab Linac Upgrade. Nuclear Physics increases 14 percent to $330.7 million with new funds for construction of the Relativistic Heavy Ion Collider (RHIC) and Continuous Electron Beam Accelerator Facility (CEBAF) and for acquistion of capital equipment for the Gammasphere and Sudbury Neutrino Observatory.

Nuclear and Renewable Energy are the prime beneficiaries of funding to secure future energy supplies. The Nuclear Energy R&D budget would increase 5 percent to $358 million. Light Water Reactor research jumps 29 percent to $31.5 with new funds for certification of General Electric's standardized Advanced Boiling Water Reactor and design, development, and testing of smaller (600 MW) passively safe advanced reactors. Advanced Reactor R&D declines 20 percent to $47 million but includes an 11 percent increase for development of the modular High Temperature Gas Reactor. Funding for Space Reactor Power Systems increases 74 percent to $54.5 million including $51 million for the SP-100 space reactor program. The Advanced Radioisotope Power System is slated for a 54 percent increase to $75.5 million for development of radioisotope power sources for space and military applications. Finally, a 17 percent reduction for Facilities to $140.5 million reflects the planned close-out of the Fast Flux Test Reactor.

The Magnetic Fusion program receives a 2 percent increase to $325.3 million designed to sustain current research and international commitments pending the outcome of a program policy review.

The overall Solar Energy Budget rises 25 percent to $115.9 million and includes increases of 26 percent for Photovoltiac Energy Systems ($43.6 million), 30 percent for Solar Thermal Energy Technology ($19.5 million) and 72 percent for Biofuels Energy Technology ($28 million). Funding for Ocean Energy Systems is eliminated.

Geothermal Energy drops $77 thousand to $18 million. One million in new funds are provided for studies and coordinating activities to address institutional impediments to development of Hydropower resources.

Funding for Electric Energy Systems increases 53 percent to $27.3 million while Energy Storage Systems increases 7 percent to $12.9 million. Included is $2.5 million for continued study of the potential health effects of electric and magnetic fields associated with power transmission.

University Research Instrumentation remains level at $4.9 million while University Research Support increases 19 percent to $29.8 million. Major shifts include the elimination of the nuclear engineering research and education program and the addition of $5 million for uranium enrichment program needs.

Finally, funding for the Clean Coal Technology demonstration program decreases 18 percent to $456 million in FY 1991. Funds are targeted for completion of second round solicitation projects and the selection of fourth round projects. Projects will demonstrate retrofit and repowering technologies to reduce pollutants and improve efficiency for better utilization of domestic coal reserves. Awardees are required to provide matching funds from non-federal sources.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA is a major beneficiary of the Administration's proposed R&D budget increases, with a FY 1991 R&D budget request of $7.07 billion, an increase of $1.83 billion.

Despite controversy in 1989, Space Station Freedom remains the cornerstone of the NASA space program with a proposed increase of 40 percent to $2.45 billion. FY 1991 marks the transition from design to actual fabrication of station hardware to enable first element launches in 1995 and a permanent manned capability by mid-1997.

Space Science and Applications will increase 24 percent to $2.48 billion. New funds go to Physics and Astronomy (up 14.4 percent to $985 million), Life Sciences (up 53.4 percent to $163 million), and Planetary Exploration (up 24 percent to $485 million). The budget supports increases for an Advanced X-Ray Astrophysics Facility and the Comet Rendezvous Asteroid Flyby/Cassini missions.

Earth Science increases 50.6 percent to $661.5 million with the addition of $103 million for the Earth Observing System (EOS), $132 million for start-up of the EOS-A platform slated for launch in 1998 to provide data on global climate change, and $25 million for Earth Probes. The budget request provides $52.8 million for Space Communications, a decrease of 34.8 percent, but includes $34 million in funding for the Advanced Communications Technology Satellite (ACTS) program.

Aeronautics Research and Technology would increase 13.8 percent to $512 million. Systems Technology programs rise 28.3 percent to $158.6 million, with significant increases for Materials and Structures Systems Technology and High-Speed Research. Space Research and Technology increases 86.4 percent to 532.9 million including $171.0 million for the Civil Space Technology Initiative.

As part of the Administration's Human Exploration Initiative, the Pathfinder program, intended to develop technologies required for an expanded human presence throughout the solar system, has been restructured as Exploration Technology and increased to $179.4 million. This effort is supported by a $37 million request for Exploration Mission Studies.

Finally, Transatmospheric Research and Technology would double to $119.0 million, and NASA Academic Programs would increase 35.3 percent to $50.1 million.

NATIONAL SCIENCE FOUNDATION

President Bush has reaffirmed a commitment to double the National Science Foundation (NSF) budget by 1993 through a series of annual 14 percent increases. The FY 91 budget calls for a 14.4 percent increase to $2.38 billion.

New funds are distributed throughout NSF's research and education directorates in support of two strategic themes: (1) strengthening the research base and improving academic research equipment and facilities, and (2) developing human resources.

The Engineering Directorate increases 12.9 percent to $226 million in FY 1991. Research priority would be given to optical high-speed communication, manufacturing design, hazards mitigation, and the processing of advanced materials including polymers, superconducters, microstructure composites and biomaterials.

Within the Engineering Directorate, funding to existing Engineering Research Centers increases 15.9 percent to $55.3 million with no new centers planned. Funding for Electrical and Communications Systems is reduced by 3.4 percent to $31.8 million. This and other cuts in Directorate activity lines reflect the shift of $16.8 million plus $8.6 million in new funds for Engineering Infrastructure Development. This new program line consolidates and strengthens activities aimed at revitalizing undergraduate engineering education, increasing the participation of women and minorities, and enhancing the educational infrastructure.

The Computer and Information Science and Engineering Directorate (CISE) is slated for a 13.8 percent increase to $193.25 million. An increase of $9.1 million is provided for Networking and Communications Research and Infrastructure to upgrade NSFNET and conduct advanced research for the National Research and Education Network (NREN) envisioned in the Federal High Performance Computing Plan. The CISE request also includes an increase of $7.76 million for four centers to upgrade hardware and software systems, improve service offerings, and perform new research on computational software for advanced scientific computing.

In other directorates, funding for the Global Geosciences Program for research on global climate change would nearly double to $85 million including an emphasis on establishment and management of databases that will be required for climate modelling. Funding for 10-12 new Science and Technology Research Centers deferred from FY 1990 is distributed through four directorates. A total of $40 million in FY 1990 and 1991 funds would be awarded for research facilities modernization.

Finally, the FY 1991 budget would preserve $9.8 million for the Experimental Program to Stimulate Competitive Research (EPSCOR) which assists states in building local resources for science and engineering.

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

The Administration has proposed a $198.4 Million budget for the National Institute of Standards and Technology, an increase of $36.5 Million. Program highlights include:

- Increases of $2.5 Million to implement the Computer Security Act of 1987, including an emergency response capability for computer viruses, and $1 Million to provide industry-wide coordination of standards for Integrated Services Digital Networks (ISDN).

- Increases of $5.5 Million for lightwave systems, $1.9 Million for high temperature superconductors, $3.9 Million for advanced semiconductors, and $5 Million for intelligent machines and processes to provide measurement technology, standards and services.

- An increase of $2.25 Million for development of measurements and standards for advanced composite materials and intelligent processing of materials.

Chapter 24

Chemical Engineering in the FY 1991 Budget

American Institute of Chemical Engineers

J.R. Hightower, Betsy Houston

This chapter attempts to identify and report on federal programs from which chemical engineers receive "significant" support. Because the budget of the United States does not specifically identify chemical engineering support, the authors draw on their experience and program descriptions given in budget justification documents for this estimate. The depth of the analysis of selected federal programs affecting chemical engineers reflects the extent to which sources were available and there was time for the authors to exploit them.

Analyses conducted by the National Science Foundation (NSF) indicate that of the total federal support for the conduct of research in chemical engineering at colleges and universities in FY 1988, 60 percent was provided by NSF, 32 percent by Department of Energy (DOE), 4 percent by the Department of Defense (DOD), and 3 percent by National Aeronautics and Space Administration (NASA). The authors' experience has shown that, indeed, NSF and DOE provide the dominant federal support for chemical engineers; but when support for all areas of chemical engineers is considered (not just those in colleges and universities), the DOE contribution dominates. Data were obtained this year for the DOE, NSF, and the Environmental Protection Agency (EPA). These data indicate that spending on programs supporting chemical engineers would decrease by 5.8 percent from $1.52 billion to $1.43 billion in FY 1991. As in the past, the totals are dominated by the DOE programs.

Department of Energy

Funding for programs important to chemical engineers in DOE is shown in Table 1. Overall, the programs decrease 7.9 percent from $1.33 billion in FY 1990 to $1.22 billion in FY 1991. Important increases are seen in Basic Energy Sciences. General decreases are seen in Conservation and Renewable Energy, Clean Coal Technology, and Fossil Energy Research and Development.

Increases in basic energy sciences include a strong emphasis on organic synthesis for synthetic metals, polymer electrolytes, high strength polymer systems, enzymatic synthesis, and the materials chemistry of high temperature superconductors. Synthesis and characterization of other novel materials of long range interest for energy systems.

Decreases in Conservation and Renewable Energy reflect changes in prioritization and emphasis on highest payoff opportunities. Funding for Nuclear R&D shows a marked increase from FY 1989 to ensure that nuclear energy remains a safe, economically competitive and environmentally acceptable resource that continues to contribute to national energy supply. The decreases in Advanced Reactor R&D represent a decrease in advanced control and robotics work and Japanese support of fuel cycle development. The budget for Fossil Energy Research reflects a perception of the need for limiting federal involvement to projects which industry cannot be expected to support.

TABLE 1. DEPARTMENT OF ENERGY
($ in millions)

	FY 1990	FY 1991	Percent Change
ENERGY SUPPLY R&D			
CONSERVATION & RENEWABLE ENERGY			
Solar Buildings Tech.	1.112	1.000	-10.1
Biofuels Energy Systems	15.500	27.000	74.2
Ocean Energy Systems	3.980	0.000	-100.0
Solar Thermal Energy Tech.			
- High Flux Photon Proc. Res.	3.320	3.780	13.9
Industrial Energy Conservation			
- Waste Energy Reduction	12.856	11.500	-10.5
- Industrial Process Efficiency	27.196	18.200	-33.1
- Industrial Cogeneration	5.073	4.100	-19.2
Transportation			
- Materials & Processing	9.401	7.500	-20.2
Energy Conservation & Utilization			
- Thermal Sciences	2.030	2.200	8.4
- Catalysis/Biocatalysis	3.955	4.000	1.1
NUCLEAR ENERGY R&D			
- Light Water Reactors	24.423	31.500	29.0
- Advanced Reactor R&D	56.784	45.000	-20.8
- Space Reactor Power Systems	31.303	54.500	74.1
- Adv. Radioisotope Power Sys.	29.777	55.500	86.4
BASIC ENERGY SCIENCES			
Materials Sciences	198.741	221.954	11.7
Chemical Sciences	140.256	150.500	7.3
Engineering & Geosciences	33.204	32.500	-2.1
CLEAN COAL TECHNOLOGY	554.000	456.000	-17.7
FOSSIL ENERGY R&D			
COAL			
Control Tech. & Coal Prep.	57.615	33.529	-41.8
Advanced Res. & Tech. Dev.	26.390	26.488	0.4
Coal Liquefaction	34.526	10.623	-69.2
Combustion Systems	33.177	17.623	-46.9
Surface Coal Gasification	23.428	8.485	-63.8
TOTAL DOE	1328.047	1223.482	-7.9

National Science Foundation

Budgets for programs in the NSF that support chemical engineers are shown in Table 2. Overall, spending for these programs are expected to increase by 10 percent, with all areas showing an increase. The Chemical and Thermal Systems (CTS) subactivity provides a substantial fraction of the federal research support to the university chemical engineering community. Within the CTS subactivity, the increases in each program budget provide increased research on the following topics:

- Within the Thermal Systems program, research on combustion and chemical processes related to processing of materials of high purity. These include magnetic stabilization of crystal melts, combustion synthesis of powdered ceramics, and environmentally compatible combustion processes.
- Within the Chemical Reaction Processes program, research on new chemical reaction processes, including: photocatalysis and electrosynthesis, sol-gel processing, processing of catalysts with molecularly engineered pore volumes and activities, and chemical processing of advanced materials.
- Within the Fluid, Particulate and Hydraulic Systems program, research on the characterization and modeling of fluid flow of such systems as polymeric solutions and particulate mixtures, with applications to thin films, coatings, ceramic slurries, and sediment flow.
- Within the Interfacial, Transport and Separations Processes program, research on the development of microporous synthetic materials for bio-separations membranes with high selectivity; processing of advanced electronic and optical materials; and separations processes of environmental importance. Also included is increased support for the thrust in microscale chemical processing.

The increase in support for the engineering research centers will be spread over the existing set of nineteen centers, considering need and performance; no new centers are planned for FY 1991. The increase for the Industry/University Cooperative Research Centers will be used to fund new university research centers aimed at broadening the program's interaction with state governments and for emerging research areas.

TABLE 2. NATIONAL SCIENCE FOUNDATION
($ in millions)

	FY 1990	FY 1991	Percent Change
CHEMICAL & THERMAL SYSTEMS			
Chemical Reaction Processes	6.600	7.000	6.1
Interfacial, Transport, & Separation Processes	7.900	8.770	11.0
Thermal Systems	7.550	8.150	7.9
Fluid, Particulate, & Hydraulic Systems	8.620	9.220	7.0
MATERIALS			
Materials Research Project Support	66.060	69.160	4.7
ENGINEERING CENTERS			
Engineering Research Centers	42.570	50.070	17.6
Industry/University Cooperative Research Centers	3.860	5.240	35.8
TOTAL NSF	143.160	157.610	10.1

Environmental Protection Agency

Total support for programs important to chemical engineers in the EPA is expected to be relatively flat as shown in Table 3. A large percent decrease (66 percent) is proposed for Environmental Engineering and Technology R&D in pesticides. All areas show little absolute change.

TABLE 3. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH AND DEVELOPMENT PROGRAMS
(Environmental Engineering and Technology Components)
($ in millions)

	FY 1990	FY 1991	Percent Change
AIR QUALITY RESEARCH	5.024	5.802	15.5
WATER QUALITY RESEARCH	3.429	3.525	2.8
DRINKING WATER RESEARCH	1.930	2.128	10.3
PESTICIDES	0.407	0.138	-66.1
TOXIC SUBSTANCES	4.963	4.460	-10.1
ENERGY	2.396	2.394	-0.1
SUPERFUND	30.355	31.304	3.1
TOTAL EPA	48.504	49.751	2.6

Chapter 25

R&D in Materials Science and Engineering

Federation of Materials Societies

Betsy Houston

Materials research and development in the proposed FY 1991 budget shows a slight increase to over $1.1 billion in the programs analyzed in this report. As the following analysis shows, funding priorities are reflected in significant increases in the materials science and engineering programs at the National Science Foundation, National Institute of Standards and Technology, and NASA, offset by a deep cut at the Department of Energy. As in past years, sufficient detail was not available at the time the report was written to include all programs with materials components.

MATERIALS R&D
(Thousands of Dollars)

	FY89	FY90	FY91
Department of Energy	$ 461,692	$ 522,326	$ 465,299
National Science Foundation	175,020	176,210	187,490
National Institute of Standards and Technology	23,544	23,157	27,295
Bureau of Mines	24,440	26,440	24,485
Department of Defense	196,387	215,892	213,323
NASA	184,158	197,969	257,700
TOTAL	$1,065,241	$1,162,044	$1,175,592

Department of Energy

Overall, the FY 1991 request for materials research and development is down by nearly $60 million. The only programs showing significant increases are the Materials Sciences subprogram of the Division of Basic Energy Sciences, and the Electric Energy Systems subprogram of the Conservation and Renewable division.

In the Materials Sciences subprogram, there is a reduction of effort on understanding processing-structure-property relationships in ceramic superconductors but a strong emphasis on organic synthesis for synthetic metals, polymer electrolytes, high strength polymer systems, enzymatic synthesis, and the materials chemistry of high temperature superconductors.

In the General Sciences Division, the materials budget for the superconducting supercollider includes finalization of the design of the superconducting dipole magnets and other technical systems.

In the Solar Energy Program, Solar Buildings Technologies activities include research on high transmittance, high thermal resistance collector aperture materials, and materials for solar cooling and dehumidification as well as daylighting. The Photovoltaics Energy systems activity will focus on three major materials groups: anorphous silicon and allloying elemens, high efficiency silicon and gallium arsenide, and advanced thin film II-VI materials.

The Electric Energy Systems and Energy Storage Systems program provides funding for electrochemical research, high temperature superconductivity materials research, battery development, and research on superconducting magnetic energy storage. Beginning in FY 1991, major emphasis will be placed on generic research for the Proton Exchange Membrane fuel cell.

In the Nuclear Energy Research and Development Program, materials are funded through the Advanced Reactor activity. Materials research in the Magnetic Fusion Program includes plasma technologies.

Fossil Energy Research and Development is the program which shows the largest decreases in materials R&D for FY 1991, primarily in fuels cells and heat engines.

In the Energy Conservation Program, materials processing research under Industrial Energy Conservation remains the same in FY 1991. Funding for the High Temperature Materials Laboratory at Oak Ridge receives a slight increase. In the Energy Conversion and Utilization Technology Program, most research areas are reduced, including ultra-tough ceramics, biobased plastics, nickel aluminide, materials processing technologies except for waste minimization, and monitoring processing of metals and ceramics.

In the Transportation Program, funds are provided through the Advanced Materials Development subprogram. The goal is to develop an industrial technology base in structural ceramics, ceramic composites, and ceramic coatings capable of providing reliable and cost-effective components for high temperature, high efficiency transportation propulsion systems while eliminating requirements for scarce strategic materials.

National Science Foundation

NSF provides about 50 percent of the federal support for university-based research in the fields of materials science and engineering. Because many materials research programs supported by other agencies are necessarily focused on areas important to their missions, NSF endeavors to provide a broad base of fundamental research support.

In the Mathematics and Physical Sciences Directorate, the Materials Research Subactivity supports research to advance the fundamental understanding of the physics and chemistry of materials, to promote the development of new materials with novel or superior properties, and to further the understanding of interrelationships among synthesis and processing, structure and composition, properties, and performance of materials at molecular, microscopic, and macroscopic levels.

In the Engineering Directorate, a special research thrust emphasizes the processing of advanced materials, including polymers, superconductors, microstructures, composites and biomaterials. These programs are spread among Chemical and Thermal Systems (processing of materials of high purity, new chemical reaction processes, characterization and modeling flow of fluids with microscopic structure with applications to thin films and coatings, development of microporous synthetic materials for bio-separation membranes, and processing of advanced electronic and optical materials); Electrical and

Communications Systems (low-temperature plasmas for plasma-assisted materials processing, advanced optoelectronic devices and materials, critical problems at the interface of optical materials, devices and systems research); Mechanical and Structural Systems (advanced processing methods for newly engineered and difficult-to-process materials); and Design and Manufacturing Systems (more advanced processing methods for newly engineered and difficult-to-process materials).

National Institute of Standards and Technology

The goals of the Materials Science and Engineering activity within the National Institute of Standards and Technology are to provide the nation with measurement methods, standards and data, and new concepts fundamental to the processing, structure, properties and performance of materials. NIST notes that this activity supports the Department of Commerce goals of (1) promoting the development of science and technology in U.S. industries and (2) increasing the acceptance of international technical standards based on U.S. technology.

Bureau of Mines

Materials related funding in the Bureau of Mines is slated for a decrease in the FY 1991 budget. The Minerals and Materials Research program is slated for a 7 percent reduction. Activities continuing to be stressed include processing and materials development - extracting mineral values and utilizing advanced materials to conserve materials resources.

Department of Defense

DoD is a major supporter of materials R&D across all its programs. Because of the breadth of involvement, it is impossible to pinpoint all the funding for materials. For example, while the various departments label one figure "materials", there are also materials-directed funds included in "university research initiatives" and other programs which could not be defined with the figures available at the time this analysis was prepared. However, a rough estimate shows that materials related R&D may have stayed essentially the same as the FY 1990 level.

National Aeronautics and Space Administration

Of the materials related programs readily identifiable in the FY 1991 budget, Materials Processing in Space is slated for a $2 million increase. The National Aerospace Plane and Space Station materials oriented funds receive and increase of 102 percent over the FY 1990 budget. Other materials efforts are spread through NASA's programs in Space Science and Applications, Space Research, and Aeronautics and Space Technology and have received a slight increase for FY 1991.

Department of Energy
(Dollars in Thousands)

	FY89	FY90	FY91
Basic Energy Sciences			
Materials Sciences	173,660	198,741	221,954
General Sciences			
Superconducting Supercollid	33,000	54,500	48,000
Conservation & Renewable			
Solar	43,221	39,973	39,600
Electric Energy Systems	27,908	22,134	33,950
Nuclear Energy			
Fuels & Materials	40,532	35,358	20,450
Magnetic Fusion			
Dev. & Technology	20,205	14,540	14,900
Fossil Energy			
Coal	57,283	67,834	20,571
Energy Conservation	65,883	91,246	65,874
TOTAL	461,692	524,326	465,299

NATIONAL SCIENCE FOUNDATION
(Dollars in Thousands)

	FY89	FY90	FY91
Mathematical and Physical Sciences			
Materials Research Project Support	64,830	66,010	69,160
Materials Research Labs & Groups	34,220	34,550	36,900
National Facilities & Instrumentation	16,030	16,330	17,400
Engineering			
Chemical and Thermal Systems	30,980	30,670	33,140
Electrical and Communications Systems	21,840	21,650	23,350
Mechanical and Structural Systems	7,120	7,000	7,540
TOTAL	$ 175,020	$ 176,210	$ 187,490

NATIONAL INSTITUTE OF STANDARDS & TECHNOLOGY

(Dollars in Thousands)

	FY89	FY90	FY91
Materials Science & Engineering	$23,544	$23,657	$27,295

BUREAU OF MINES

(Dollars in Thousands)

	FY89	FY90	FY91
Minerals & Materials Research	24,440	26,440	24,485

DEPARTMENT OF DEFENSE

(Dollars in Thousands)

	FY89	FY90	FY91
Army	$ 59,698	$ 55,706	$ 61,242
Navy	33,182	26,889	22,011
Air Force	58,690	66,328	75,889
DARPA	47,547	66,969	54,191
TOTAL DoD	$196,387	$215,892	$213,333

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

(Dollars in Thousands)

	FY89	FY90	FY91
Materials Processing in Space	$ 75,600	$ 99,000	$ 97,300
Transatmospheric Research and Technology	69,400	59,000	119,000
Materials and Structures Research and Technology	39,158	39,969	41,400
TOTAL NASA	$184,158	$197,969	$257,700

Chapter 26

Mechanical Engineering in the FY 1991 Budget

American Society of Mechanical Engineers

Nelson Milder, Janis Tabor

Introduction

This report provides an overview of mechanical engineering research and development (R&D) funding as proposed in the FY 1991 federal budget. Only programs likely to include substantial mechanical engineering components are addressed but, since the federal budget does not itemize engineering R&D by discipline, the precise mechanical engineering portion of each program cannot be specified. Therefore, this review should be used as a guide to general trends in federal funding for mechanical engineering R&D rather than a comprehensive accounting of all funding proposed for mechanical engineering research.

Mechanical engineering (ME) R&D programs included in this analysis would see a total funding increase of 7.2 percent under the Bush Administration's FY 1991 plan. With the exception of budget hits for ME R&D at the Department of Energy and Environmental Protection Agency, and despite the strong likelihood of Gramm-Rudman-Hollings sequestration cuts in October, the overall picture looks relatively good.

The greatest change is a proposed 37.3 percent increase in funding for ME programs at the National Institute of Standards and Technology (to $99.79 million), followed by a boost of 33.9 percent for ME activities at the National Aeronautics and Space Administration (to $6.854 billion, including a hefty $2.451 billion for Space Station Freedom). ME programs at the National Science Foundation are up 12.7 percent (to $125.65 million) but the agency has had to postpone its goal of doubling the overall budget until FY 1994, a two-year delay. While the 3 percent increase in Defense Department ME R&D programs falls a bit shorter than the others, its ME R&D budget total of $29.312 billion still leads the pack. ME R&D losers this year are the Department of Energy (down 12.3 percent, to $955.1 million, reflecting significant reductions in fossil and conservation programs) and the Environmental Protection Agency (reduced by 11.2 percent, to $60.35 million, including a substantial cut in Superfund).

Department of Energy

Civilian research and development programs within the Department of Energy FY 1991 budget request of importance to mechanical engineering total $955.1 million, a 12.3 percent reduction from the FY 1990 appropriated level of $1.09 billion. The reductions are primarily due to proposed cuts in the coal research program of nearly $165 million from the FY 1990 appropriation of $275.3 million and decreases in the conservation program amounting to nearly $20 million.

Solar energy programs would receive a substantial boost, from $89.7 million in FY 1990 to $115.9 million, including a 72 percent increase for biofuels energy technology. Wind energy systems funding is significantly reduced, with no funding provided for the ocean energy systems program in FY 1991. The Basic Energy Sciences (BES) program would receive an overall increase of 14 percent. Of particular concern to mechanical engineering, however, are the decreases in materials science and engineering research programs. The major increase in the BES request is for user facilities at the national laboratories.

The nuclear energy R&D program would increase slightly, with the most significant growth occurring in the space reactor power systems and advanced radioisotope power systems programs. These include the SP-100 thermoelectric space power reactor development and the radioisotope thermoelectric generators (RTG) for NASA and DOD. Funding for advanced reactor research and development would decline by 20 percent from the FY 1990 appropriation of $58.8 million, to $47 million.

TABLE I

Department of Energy
(Thousands of Dollars)

	Actual FY 1989	Est. FY 1990	Proposed FY 1991
Basic Energy Sciences			
Engineering Research	15,152	15,354	15,022
Materials Science	126,149	143,380	141,522
Fossil Energy			
Coal	242,296	275,259	110,338
Gas	11,384	14,429	13,674
Petroleum	38,314	39,913	40,697
Conservation			
Building Systems	10,899	10,964	16,690
Community Systems	3,060	4,094	772
Tech. & Cons. Products	12,243	14,016	10,674
Appliance Standards	1,673	1,780	2,000
Fed. Energy Management	1,000	1,187	3,000
Waste Energy	11,150	12,856	11,500
Industry Process Eff.	9,350	27,196	18,200
Industry Cogeneration	4,600	5,073	4,100
Vehicle Propulsion	16,323	17,385	11,400
Energy Conversion	22,743	26,404	22,900
Other			
Solar	89,069	89,659	115,873
Geothermal	19,321	18,077	18,000
Electric Energy Systems	24,316	17,828	27,347
Energy Storage Systems	11,868	12,047	12,906
Nuclear Energy	347,508	341,847	357,790
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Total	1,019,418	1,088,808	955,065

National Science Foundation

Research programs involving mechanical engineering at NSF would grow about 12.7 percent over the FY 1990 level. This is less than the 14.4 percent increase proposed for NSF as a whole and slightly less than the 12.9 percent rise slated for overall engineering research at the Foundation.

However, as indicated in Table II, of the $14 million increase for ME research, over half, or $8.9 million, is for the Engineering Centers, of which an indeterminate portion is specifically related to mechanical engineering. The traditional, individual investigator-oriented research programs involving mechanical engineering would only increase 8 percent, from $65.1 million in FY 1990 to $70.3 million in FY 1991.

Proposed funding for the categories listed in Table II represent fairly uniform and modest increases. Areas of special interest for FY 1991 include Engineering Infrastructure Development, Global Change research and a continuation of the U.S. Antarctic Program.

TABLE II

National Science Foundation
(Millions of Dollars)

	Actual FY 1989	Est. FY 1990	Proposed FY 1991
Mech. & Struc. Systems			
Dynamic Sys. & Cont.	3.18	3.13	3.35
Struc. & Building Sys.	6.66	6.62	7.10
Mat. Eng. & Tribology	7.12	7.00	7.54
Solid and Geomechanics	6.08	5.45	6.42
Design and Mfg. Systems			
Oper. Res. & Prod. Sys.	4.69	5.00	5.71
Design & Computer-Int. Engineering	6.02	5.94	6.33
Mfg. Process & Equipment	7.35	7.35	7.74

TABLE II (Continued)

National Science Foundation
(Millions of Dollars)

Chemical & Thermal Systems			
Interfacial Transp. & Separation Processes	7.62	7.90	8.78
Thermal Systems	7.80	7.55	8.15
Fluid, Part. & Hydraulic Sys.	8.81	8.62	9.22
Engineering Centers			
Engineering Res. Centers	37.18	42.58	50.07
Industry/Univ. Cooperative Research Centers	3.25	3.86	5.24
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Total	105.76	111.50	125.65

National Aeronautics and Space Administration

Of the $15.1 billion requested by NASA for FY 1991, research and development activities involving mechanical engineering are estimated at $6.8 billion, a 33.9 percent increase over the amount appropriated in FY 1990. As was the case last year, the largest portion of this request is for the Space Station Freedom program.

Two new major initiatives -- the Earth Observing System and new technology (including robotic science missions) to enable human exploration beyond Earth orbit -- account for nearly $1 billion of the R&D request (base program plus additions). The Space Science and Applications Program includes $103 million of the Earth Observing system. The Hubble Space Telescope is scheduled for launch on the Space Shuttle in March, 1990. The Ulysses mission is scheduled for launch in October of this year. The major new planetary missions are the CRAF/Cassini Missions which have strong international cooperation. Activities in FY 1991 include continuation of design and development work on the spacecraft to meet August, 1995 (CRAF) and April, 1996 (Cassini) launch dates.

Funding for the Transatmospheric Research and Technology program, which supports the joint NASA/DOD

National Aerospace Plane (NASP) program, would double to $119 million in FY 1991 with the bulk of the increase supporting contracted studies on vehicle-concept development and engine development. The Space Research and Technology Program would grow by $210 million to cover increases in the Civilian Space Technology Initiative and the Exploration Technology Experiments program. These programs include work in artificial intelligence and telerobotics, propulsion (including nuclear propulsion) and in-space operations, such as structure assembly, construction and repair in near-Earth orbit.

TABLE III

National Aeronautics and Space Administration
(Millions of Dollars)

	Actual FY 1989	Est. FY 1990	Proposed FY 1991
Space Station	900.0	1749.6	2451.0
Space Transp. & Capability	674.0	562.4	773.4
Space Science & Applications			
Physics & Astronomy	737.1	861.4	985.0
Planetary Exploration	416.6	391.7	485.2
Space Applications (incl. Earth Observing Sys.)	591.1	644.5	848.4
Commercial Programs	44.7	56.5	101.0
Aeronautical Res. & Tech.	398.2	449.7	512.0
Space Research & Tech.	285.9	285.9	495.9
Transatmospheric Res. & Tech.	69.4	59.0	119.0
Safety Reliability & Quality Assurance	22.4	22.6	33.0
Academic Programs	23.6	37.0	50.1
Total	4,163.3	5,120.3	6,854.0

National Institute of Standards and Technology

The FY 1991 request of $198.4 million for NIST contains an overall $36.5 million increase over last year -- an unaccustomed boost for this Commerce Department agency. A healthy share of the increase is allocated to core R&D programs herein considered relevant to mechanical engineering. Among these programs, it is of particular note that this year's request does not contain the near-lethal cuts for Fire and Building Research programs that have characterized requests of the last several years.

The programs listed in Table IV are concentrated in NIST's Measurement Research and Standards, Materials Science and Engineering, and Engineering Measurements and Standards activities. The most significant single increase is for Analytical and Chemical Measurements and Standards, for which a 106 percent hike from $4.3 million to $8.8 million is proposed. The increase will support several new projects from a list of 13 priorities developed with industry input. Under Engineering Measurements and Standards, the Manufacturing Research and Standards area would receive an 89 percent increase (to $11.8 million) and Electronics and Electrical Measurements is slated for a 74 percent increase (to $28.2 million.) The $9.3 million request for Fire and Building Research, while essentially level with the FY 1990 appropriation, is in marked contrast with last year's request of $5 million.

Not shown on the Table is the funding picture for Industrial Technology Services, which includes the Manufacturing Technology Centers and the Advanced Technology Programs (ATP). The Administration's proposal would decrease funding for the Centers by one-third, to a new level of $5 million, and maintain ATP at $10 million. It does not appear that there will be any funding conflicts between the new technology programs and core R&D programs as Congress works out details of the FY 1991 budget.

TABLE IV

National Institute of Standards and Technology
(Thousands of Dollars)

	Actual FY 1989	Est. FY 1990	Proposed FY 1991
Analyt. Chem. Meas. & Stds.	4,379	4,261	8,789
Chemical Prop. & Process	11,224	11,553	14,358
Materials Sci. & Eng.	23,544	25,157	27,295
Manuf. Res. & Stand.	6,236	6,233	11,786
Electronics & Elec. Meas.	16,104	16,197	28,243
Fire and Building Res.	9,453	9,271	9,321
Total	70,940	72,672	99,792

Environmental Protection Agency

A substantial net reduction in funding is projected for research involving mechanical engineering at EPA. However, this hit reflects cuts in the two largest categories only: Superfund and Hazardous Waste. Superfund, which represents over half of the research budget related to mechanical engineering, is scheduled for a 20.9 percent decrease due to a shift in program priorities toward enforcement and on-site response. Hazardous waste is being reduced because EPA research on land disposal methods and technology is now complete.

EPA's Air program is targeted for a 17.9 percent increase, primarily to support implementation of the Clean Air Act Amendments. This includes research on the effects of alternative fuels on air quality, emissions inventory methods, and global climate change. In contrast, Energy research will increase only marginally in 1991. Following issuance of the 1990 National Acid Precipitation Assessment Program, research on acid rain will decline by over half, but research will continue on the Limestone Injection Multistage Burner Air Emission Control Technology program.

Water quality research will concentrate on wetlands preservation and oil spill cleanup technology. Radiation program research is planned in the areas of mitigation of human exposure to radon, and off-site monitoring around nuclear test sites. The toxic substances research program will support the Toxic Substances Control Act and provide engineering studies in biotechnology.

TABLE V

Environmental Protection Agency
(Thousands of Dollars)

	Actual FY 1989	Est. FY 1990	Proposed FY 1991
Air	3,035.2	4,919.6	5,802.2
Water Quality	3,213.8	3,335.1	3,525.6
Hazardous Waste	11,222.7	13,639.5	12,426.4
Radiation	2,170.7	2,258.1	2,519.5
Toxic Substances	1,641.2	1,923.4	2,375.7
Energy	2,402.2	2,298.6	2,393.7
Superfund	31,639.5	39,590.7	31,303.9
Total	55,325.3	67,965.0	60,347.0

Department of Defense

This report provides only a broad overview of R&D funding at DOD since mechanical engineering is involved in most defense programs. The proposed FY 1991 budget, as part of a two-year budget system, also represents primarily a continuation of the existing FY 1990 programs.

As part of the overall Defense budget, R&D programs may be subject to future evaluation in light of changing defense requirements, particularly as political events in the Soviet Union and in Eastern Europe continue to unfold. Further, the Strategic Defense Initiative program and four major aircraft programs are currently under review.

Programs at three of the major branches -- Army, Navy and Air Force -- would receive slight increases according to the FY 1991 budget request. Funding for Other Agencies would be down slightly. Areas of continuing interest include the physical sciences, materials, electronics, and the joint DOD/NASA Aerospace Plane.

TABLE VI

Department of Defense
Research and Development
(Millions of Dollars)

	Actual FY 1989	Est. FY 1990	Proposed FY 1991
Research	950.7	923.5	977.8
Exploratory Development	2,540.8	2,403.1	2,457.5
Advanced Development	10,375.6	10,340.3	11,106.8
Engineering Development	11,413.3	11,301.9	10,941.7
Management & Support	2,808.5	2,530.1	2,849.1
Total	28,088.9	27,498.9	28,332.9

TABLE VII

Department of Defense
Basic Research
(Millions of Dollars)

	Actual FY 1989	Est. FY 1990	Proposed FY 1991
Army	170.9	181.6	188.9
Navy	352.4	365.9	401.2
Air Force	197.2	189.6	201.5
Other Agencies	230.2	186.3	186.3
Total	950.7	923.4	977.9

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Colloquium Proceedings: 1976–1982 and 1984–1989

From 1976 through 1982, the annual AAAS R&D Colloquia were held in June; from 1984 through 1986, in March; and since 1987, in April, following publication of the latest *R&D Report*. The *Proceedings* of these Colloquia were published separately each year and, in general, include the texts of speeches delivered during the meetings and in some cases edited versions of the discussions that followed. (The *Proceedings* of the 1983 Colloquium are included in *AAAS Report VIII*).

Preliminary Analyses: FY 1979–FY 1984

Prepared by an Intersociety Working Group comprised of representatives of several scientific, engineering and higher education associations, these reports review, in a preliminary fashion, the overall federal budget for R&D, the R&D budgets of several major R&D agencies, and the R&D funding situation in a number of scientific and engineering disciplines. In general, they are published within a few weeks after release of a given year's budget.

Congressional Action on R&D in the Federal Budget: FY 1979–FY 1990

These brief reports, published in the fall, are also prepared in collaboration with the Intersociety Working Group. They summarize the results of congressional action on R&D elements in the federal budget. Their format permits comparison between the President's proposals for a given fiscal year and congressional allocations.

R&D in the 1980s: A Special Report

This report, prepared in the fall of 1988, reviews the history of R&D policy and funding in the Reagan years.